



Herbal Remedies for Acne: A Review of Phytoconstituents and Clinical Evidence

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ABSTRACT :

Acne vulgaris is a multifactorial inflammatory skin condition that affects a significant portion of the global population, particularly adolescents and young adults. Conventional therapies, including antibiotics, retinoids, and hormonal agents, often lead to side effects, antimicrobial resistance, and poor patient compliance, necessitating the exploration of safer and more sustainable alternatives. In recent years, herbal remedies have gained popularity due to their multi-targeted actions, minimal side effects, and traditional acceptance. This review explores the pathophysiology of acne, conventional treatment drawbacks, and the therapeutic potential of various medicinal plants such as *Azadirachta indica*, *Melaleuca alternifolia*, *Curcuma longa*, and *Aloe vera*. Their phytoconstituents—flavonoids, alkaloids, terpenoids, and phenolics—demonstrate antimicrobial, anti-inflammatory, antioxidant, and sebostatic activities. Evidence from in vitro, in vivo, and limited clinical studies supports their efficacy, though challenges such as standardization, clinical validation, and regulatory concerns persist. Future perspectives suggest the need for rigorous trials, novel delivery systems, and integration with conventional therapies to establish herbal agents as reliable acne treatments. This review highlights the promising role of phytomedicine in acne management and underscores the importance of evidence-based herbal dermatology.

Keywords : Acne vulgaris; Herbal remedies; Phytoconstituents; Anti-inflammatory; Antibacterial; *Azadirachta indica*; *Curcuma longa*; Natural therapy; Skin disorders; Alternative medicine

1. Introduction

Acne vulgaris is a **chronic inflammatory skin disorder** primarily affecting the **pilosebaceous units**, which are composed of hair follicles and sebaceous glands. It is one of the most common dermatological conditions globally, particularly affecting **adolescents and young adults**. The pathogenesis of acne involves four main factors: **increased sebum production**, **abnormal follicular keratinization**, **colonization by *Cutibacterium acnes* (formerly *Propionibacterium acnes*)**, and **inflammatory responses** (Zaenglein et al., 2016).

The **clinical manifestations** of acne include **comedones (blackheads and whiteheads)**, **papules**, **pustules**, **nodules**, and **cysts**, which can vary in severity. These lesions typically appear on the **face, chest, shoulders, and back**, areas rich in sebaceous glands. While acne is most prevalent during adolescence, it can persist or newly develop in adults, especially among **women due to hormonal fluctuations** (Tan et al., 2016).

Conventional treatments for acne include **topical agents** such as **retinoids**, **benzoyl peroxide**, and **antibiotics**, as well as **oral therapies** like **antibiotics**, **hormonal agents**, and **isotretinoin**. Although these treatments are often effective, they are associated with several **limitations**, including **skin irritation**, **photosensitivity**, **antibiotic resistance**, and **systemic side effects** (Gollnick et al., 2015; Thiboutot et al., 2018). Moreover, the long-term use of antibiotics has raised significant concerns about **microbial resistance**, prompting the need for alternative or adjunct therapies (Zaenglein et al., 2016).

In recent years, there has been a **growing interest in herbal and natural remedies** for acne due to their **milder side-effect profiles**, **lower cost**, and **historical usage in traditional medicine systems** such as Ayurveda and Traditional Chinese Medicine. Various **medicinal plants** have been studied for their **antimicrobial**, **anti-inflammatory**, **antioxidant**, and **sebostatic** activities that can target multiple pathways in acne pathogenesis (Khan et al., 2020; Pan et al., 2021).

The objective of this review is to provide a comprehensive overview of **herbal remedies used in the treatment of acne**, focusing on **bioactive phytoconstituents** and the available **clinical and experimental evidence** supporting their efficacy. The review also highlights the **mechanisms of action**, **formulation trends**, and **future directions** in herbal acne therapy.

2. Pathophysiology of Acne

Acne vulgaris is a multifactorial skin disorder characterized by a complex interplay of **biological, microbial, and hormonal factors** that lead to inflammation and follicular plugging within the pilosebaceous unit. The four primary pathogenic factors involved in acne development are: **increased sebum production**, **hyperkeratinization**, **microbial colonization**, and **inflammatory responses** (Thiboutot et al., 2009; Zaenglein et al., 2016).

Sebum Overproduction

Sebaceous glands, influenced by androgenic hormones such as *testosterone* and *dihydrotestosterone (DHT)*, become hyperactive during puberty and adolescence. This results in *excessive sebum secretion*, which creates a lipid-rich environment that supports microbial proliferation (Ottaviani et al., 2010). Sebum itself is not inherently harmful but can become comedogenic when altered by lipid peroxidation, contributing to *follicular occlusion* (Picardo et al., 2009).

Follicular Hyperkeratinization

In acne-prone individuals, the process of *keratinocyte differentiation and desquamation* becomes abnormal. This leads to *retention hyperkeratosis*, wherein dead skin cells are not shed properly and accumulate within the hair follicle, forming a *microcomedo* — the initial lesion in acne (Liu et al., 2014). These plugged follicles become the site for bacterial colonization and inflammation.

Microbial Colonization – *Cutibacterium acnes*

Cutibacterium acnes (formerly *Propionibacterium acnes*) is a *Gram-positive anaerobic bacterium* that resides in the pilosebaceous unit. It contributes to acne by:

- Hydrolyzing *sebum triglycerides* into pro-inflammatory free fatty acids,
- Activating *toll-like receptors (TLR-2)* on keratinocytes and macrophages,
- Inducing the *release of cytokines and chemokines* (e.g., IL-1, IL-8, TNF- α), which promote local inflammation (Kistowska et al., 2014; Dréno et al., 2015).

The *biofilm-forming capacity* of *C. acnes* also makes it more resistant to antimicrobial therapy, complicating treatment (Jahns et al., 2012).

Inflammatory Response

Inflammation plays a central role in both *non-inflammatory (comedonal)* and *inflammatory (papules, pustules, nodules)* acne lesions. The innate immune response is triggered by microbial metabolites and host-derived lipids, resulting in *neutrophil infiltration* and activation of *pro-inflammatory mediators* such as *IL-1 β* , *TNF- α* , and *reactive oxygen species (ROS)* (Kircik et al., 2016). Chronic inflammation contributes to *post-acne scarring and pigmentation*, especially in darker skin types.

Hormonal Factors

Hormones, especially *androgens*, are central to the pathogenesis of acne. Androgens stimulate *sebaceous gland hypertrophy* and increase sebum production. This is particularly relevant in *adolescent acne*, *polycystic ovary syndrome (PCOS)*, and *perimenstrual flares* in women (Lucky et al., 1994). Elevated insulin-like growth factor-1 (IGF-1) has also been implicated in acne development, especially in connection with high glycemic index diets (Melnik et al., 2013).

Oxidative Stress

Recent studies have linked *oxidative stress* to the severity of acne vulgaris. Excess ROS can *damage cell membranes*, modify lipids in sebum, and amplify the inflammatory response (Yoon et al., 2004). A decrease in cutaneous antioxidants like *vitamin E*, *glutathione*, and *superoxide dismutase* has been observed in acne patients (El-Akawi et al., 2006), suggesting a potential therapeutic role for *antioxidant-based treatments*.

3. Role of Herbal Medicine in Acne Treatment

The limitations of conventional acne therapies—including *antibiotic resistance*, *skin irritation*, *teratogenicity* (as in isotretinoin), and high relapse rates—have prompted growing interest in *herbal and plant-based therapies*. Herbal medicine offers a *multimodal approach* to acne management by targeting the *core pathogenic mechanisms*, including microbial growth, inflammation, sebum production, and oxidative stress (Sivarajan et al., 2012; Draelos et al., 2005).

3.1 Historical and Traditional Use of Herbs

For centuries, *traditional medicine systems* such as *Ayurveda*, *Traditional Chinese Medicine (TCM)*, and *Unani* have used medicinal plants for treating skin conditions like acne. Herbs such as *Azadirachta indica* (neem), *Curcuma longa* (turmeric), and *Aloe vera* have long been employed for their *blood-purifying*, *antiseptic*, and *cooling properties* (Kumar et al., 2013). These practices laid the foundation for modern scientific investigation into herbal anti-acne agents.

3.2 Mechanisms of Action

Many medicinal plants contain *bioactive phytochemicals* such as *flavonoids*, *alkaloids*, *saponins*, *terpenoids*, and *polyphenols* that possess *antibacterial*, *anti-inflammatory*, *antioxidant*, and *wound-healing* properties (Nair et al., 2020; Ashraf et al., 2015). These compounds work through:

- **Antimicrobial action:** Herbal extracts can inhibit *Cutibacterium acnes* and other skin pathogens by disrupting bacterial cell membranes and biofilm formation (Siddiqui et al., 2018).
- **Anti-inflammatory effect:** Flavonoids, curcuminoids, and other compounds downregulate inflammatory cytokines such as IL-1 β and TNF- α , reducing lesion severity (Goh et al., 2016).
- **Sebum regulation:** Certain plant extracts (e.g., green tea polyphenols) have been shown to *inhibit 5 α -reductase*, thereby reducing sebum production (Yoon et al., 2013).
- **Antioxidant activity:** Phytochemicals scavenge *reactive oxygen species (ROS)*, which helps mitigate oxidative damage in acne lesions and prevents further inflammation (Hafeez et al., 2014).

3.3 Benefits of Herbal Remedies

Herbal formulations are generally considered *safer, milder, and more biocompatible* than synthetic agents. They tend to have *fewer side effects*, and many are *suitable for long-term use*, especially in *sensitive skin types* (Bhowmik et al., 2012). Additionally, plant-based ingredients are *eco-friendly*, and their integration into *cosmeceutical products* (like creams, face washes, and serums) has gained popularity in both dermatology and the cosmetic industry.

3.4 Growing Scientific Interest

Modern research has started validating the efficacy of various *herbal extracts through in vitro, in vivo, and clinical studies*. For example, *Melaleuca alternifolia* (tea tree oil) has shown comparable efficacy to benzoyl peroxide in reducing acne lesions, with fewer reports of skin irritation (Bassett et al., 1990). Similarly, *Aloe vera*, *Calendula officinalis*, and *Camellia sinensis* have demonstrated significant *anti-acne potential* in scientific evaluations (Rajeswari et al., 2012; Ebrahimzadeh et al., 2014).

4. Key Medicinal Plants and Their Phytoconstituents

Numerous *medicinal plants* have been investigated for their efficacy in acne management due to their *broad-spectrum antimicrobial activity*, *anti-inflammatory properties*, and *bioactive phytoconstituents*. Below is a summary of well-documented anti-acne herbs and their major active compounds.

4.1 Selected Medicinal Plants and Their Active Components

Botanical Name	Common Name	Major Phytoconstituents	Reported Anti-Acne Activities
<i>Azadirachta indica</i>	Neem	Nimbidin, Azadirachtin, Quercetin	Antibacterial, anti-inflammatory, antioxidant (Biswas et al., 2002)
<i>Melaleuca alternifolia</i>	Tea Tree	Terpinen-4-ol, γ -terpinene	Antibacterial, sebum regulation (Carson et al., 2006)
<i>Curcuma longa</i>	Turmeric	Curcumin, Demethoxycurcumin	Anti-inflammatory, antioxidant (Chainani-Wu, 2003)
<i>Aloe vera</i>	Aloe	Aloin, Emodin, Polysaccharides	Healing, anti-inflammatory, moisturizing (Surjushe et al., 2008)
<i>Eclipta alba</i>	Bhringraj	Wedelolactone, Luteolin, Flavonoids	Antimicrobial, anti-inflammatory (Chaudhary et al., 2011)
<i>Camellia sinensis</i>	Green Tea	Epigallocatechin gallate (EGCG), Catechins	Sebum regulation, antioxidant, anti-inflammatory (Yoon et al., 2013)
<i>Calendula officinalis</i>	Marigold	Flavonoids, Triterpenoids, Saponins	Antibacterial, wound healing (Preethi et al., 2009)
<i>Glycyrrhiza glabra</i>	Licorice	Glycyrrhizin, Liquiritin	Anti-inflammatory, skin lightening (Alyoussef et al., 2017)

4.2 Mechanism-Based Phytochemical Action

- **Flavonoids** (e.g., quercetin, catechins) exhibit potent *antioxidant* and *anti-inflammatory* effects by inhibiting ROS generation and suppressing pro-inflammatory cytokines (Panche et al., 2016).
- **Terpenoids** (e.g., azadirachtin, terpinen-4-ol) possess *antimicrobial activity*, particularly effective against *C. acnes* by disrupting bacterial cell membranes (Hammer et al., 2003).
- **Curcuminoids** from turmeric act via *NF- κ B pathway suppression*, leading to reduced inflammation (Aggarwal et al., 2007).
- **Polysaccharides and saponins** enhance skin hydration and accelerate wound healing, aiding in post-acne recovery (Bunyaphatsara et al., 1996).

4.3 Synergistic Potential

Many herbal formulations combine multiple extracts to achieve a *synergistic effect*—enhancing antimicrobial and healing properties while minimizing irritation. For example, a combination of *neem and turmeric* or *aloe vera and tea tree oil* has shown enhanced efficacy in both clinical and experimental studies (Rajeswari et al., 2012; Malhi et al., 2020).

5. Mechanism of Action of Phytoconstituents in Acne Management

The therapeutic potential of herbal remedies in acne lies in their *phytoconstituents*, which interact with multiple targets within the acne pathophysiology pathway. These bioactive compounds—such as flavonoids, alkaloids, terpenoids, and phenolics—exert their effects via *antibacterial*, *anti-inflammatory*, *antioxidant*, *sebostatic*, and *wound-healing* mechanisms (Nair et al., 2020; Hafeez et al., 2014).

5.1 Antibacterial Activity

Several herbal extracts demonstrate potent activity against *Cutibacterium acnes* and other skin microbes. For example:

- *Terpinen-4-ol* in tea tree oil disrupts the bacterial cell membrane, inhibiting growth and biofilm formation (Carson et al., 2006).
- *Azadirachtin* and *nimbidin* from neem exhibit broad-spectrum antimicrobial effects by altering bacterial cell walls and reducing virulence factor expression (Biswas et al., 2002).
- *Curcumin* from turmeric interferes with bacterial quorum sensing and reduces bacterial proliferation (Chainani-Wu, 2003).

5.2 Anti-inflammatory Effects

Acne inflammation results from immune responses to bacterial metabolites and comedone rupture. Many phytoconstituents modulate key inflammatory mediators:

- *Curcuminoids*, *flavonoids*, and *luteolin* inhibit the *NF-κB signaling pathway*, thereby reducing the expression of pro-inflammatory cytokines like TNF-α, IL-1β, and IL-6 (Aggarwal et al., 2007).
- *Licorice flavonoids* suppress *COX-2 enzyme expression* and prostaglandin synthesis, further limiting inflammation (Alyoussef et al., 2017).

5.3 Antioxidant Defense

Oxidative stress contributes to acne by degrading sebum lipids and enhancing inflammation. Herbal antioxidants:

- *Quercetin*, *epigallocatechin gallate (EGCG)*, and *vitamin C derivatives* scavenge *reactive oxygen species (ROS)*, protect cellular lipids and proteins, and maintain cutaneous antioxidant balance (Yoon et al., 2004; Panche et al., 2016).
- *Aloe vera polysaccharides* and *wedelolactone* from *Eclipta alba* have demonstrated protective effects against oxidative damage (Chaudhary et al., 2011).

5.4 Sebum Regulation

Androgens stimulate sebaceous gland activity, a major contributor to acne. Some phytochemicals act as *natural 5α-reductase inhibitors*:

- *Green tea polyphenols (EGCG)* and *saw palmetto extracts* have been shown to suppress androgen receptor activity and reduce sebum production (Yoon et al., 2013).
- *Curcumin* may indirectly regulate lipid synthesis by modulating peroxisome proliferator-activated receptor gamma (PPAR-γ) signaling (Jurenka, 2009).

5.5 Wound Healing and Skin Regeneration

Herbs also support post-acne recovery and scar prevention:

- *Aloe vera*, *calendula*, and *gotu kola (Centella asiatica)* promote *fibroblast proliferation*, *collagen synthesis*, and *angiogenesis*, accelerating wound closure (Surjushe et al., 2008; Preethi et al., 2009).
- *Saponins and tannins* act as natural astringents and aid in tissue regeneration and skin barrier repair (Bunyapraphatsara et al., 1996).

6. Clinical Evidence and Experimental Studies

Numerous *in vitro*, *in vivo*, and *clinical trials* have been conducted to validate the *efficacy and safety* of herbal medicines for acne treatment. These studies have assessed the antimicrobial, anti-inflammatory, antioxidant, and sebum-reducing properties of various plant extracts and their active compounds, confirming their potential as alternatives or adjuncts to conventional therapies.

6.1 In Vitro Studies

- *Neem (Azadirachta indica) extract* exhibited significant antibacterial activity against *Cutibacterium acnes* and *Staphylococcus epidermidis*, with inhibition zones ranging from 7–11 mm, supporting its use in anti-acne formulations (Siddiqui et al., 2018).
- *Tea tree oil (Melaleuca alternifolia)* demonstrated dose-dependent inhibition of *C. acnes*, attributed mainly to terpinen-4-ol, its major constituent (Hammer et al., 2003).
- *Curcumin*, tested against acne-causing bacteria, showed effective suppression of inflammatory markers such as IL-6 and TNF- α in cultured human keratinocytes (Chainani-Wu, 2003).
- *Green tea polyphenols (EGCG)* were found to reduce sebum production in sebocyte cell lines and inhibit the proliferation of acne-causing bacteria (Yoon et al., 2013).

6.2 Animal Studies

- In a murine model, *topical application of turmeric extract* significantly reduced the number and severity of acneiform lesions induced by *C. acnes*, likely due to its anti-inflammatory and antioxidant actions (Kim et al., 2010).
- *Aloe vera gel* demonstrated wound-healing activity and inflammation reduction in acne-induced rabbit ear models (Heggens et al., 1996).

6.3 Human Clinical Trials

- In a *randomized controlled trial*, 5% tea tree oil gel significantly reduced inflammatory and non-inflammatory acne lesions compared to placebo, with fewer adverse effects than benzoyl peroxide (Bassett et al., 1990).
- A *combination of turmeric and sandalwood oil cream* applied twice daily for 8 weeks showed marked improvement in acne severity in adolescents, with over 70% reduction in lesion count (Pattanayak et al., 2012).
- *Green tea extract lotions* applied topically twice daily led to decreased sebum excretion and reduced papule count in adult acne patients over a 6-week period (Yoon et al., 2013).
- A clinical study involving *licorice gel (2%)* found it effective in reducing acne lesions and erythema, with good patient tolerance and no major side effects (Alyoussef et al., 2017).

6.4 Comparative Efficacy with Synthetic Drugs

In many cases, herbal formulations have shown *comparable efficacy* to conventional treatments like *benzoyl peroxide*, *clindamycin*, and *retinoids*, but with *lower irritation potential* and *better compliance* (Draelos et al., 2005). This has prompted the development of *herbal cosmeceutical products*, such as anti-acne gels, face washes, and creams that integrate standardized plant extracts.

7. Challenges and Limitations

While herbal remedies offer promising alternatives in acne management, several *challenges and limitations* affect their broader acceptance and clinical application. These issues stem from *scientific, regulatory, and practical considerations*.

7.1 Lack of Standardization

One of the major hurdles in herbal medicine is the *lack of standardization* in extract preparation. The concentration of active constituents can vary due to:

- Plant source and geographical origin
- Harvesting time and storage conditions
- Extraction and formulation techniques
- This variability makes it difficult to *reproduce results*, assess true efficacy, or compare different studies (Sahoo et al., 2010).

7.2 Insufficient Clinical Trials

Most evidence for herbal anti-acne agents is based on *in vitro* or *animal studies*, with relatively *few large-scale, randomized clinical trials* conducted on humans. Limited sample sizes, short treatment durations, and lack of long-term follow-up affect the *quality and generalizability* of results (Sharma et al., 2013).

7.3 Regulatory and Safety Concerns

Unlike synthetic drugs, herbal products often *lack rigorous regulatory oversight*, especially in developing countries. This leads to:

- Adulteration and contamination with heavy metals or microbes
- Inaccurate labeling of ingredients or concentrations
- Variability in safety profiles due to unregulated production processes (WHO, 2004)

Although most herbs are perceived as “safe,” some may cause:

- *Allergic reactions*, especially in sensitive skin
- *Photosensitivity*, particularly with citrus oils
- *Systemic toxicity*, if taken orally in large doses or with drug interactions (Patel et al., 2012)

7.4 Poor Patient Compliance

While herbal treatments may be safer, they sometimes have:

- *Slower onset of action*
- *Longer treatment duration*
- *Strong odors or staining potential* (e.g., turmeric)

These factors can affect *patient satisfaction and adherence* to treatment regimens (Draeos et al., 2005).

7.5 Scientific Validation of Traditional Claims

Many traditional herbal uses are based on *ethnobotanical or anecdotal evidence*. However, the *scientific validation* of such claims is often lacking due to:

- *Inadequate phytochemical profiling*
- *Unclear mechanisms of action*
- *Absence of dose-response data* (Mukherjee et al., 2001)

7.6 Intellectual Property and Ethical Concerns

The increasing commercial interest in herbal products raises concerns over:

- *Biopiracy* – using traditional knowledge without fair compensation
- *Lack of benefit sharing* with indigenous communities who have preserved plant knowledge for generations (Ten Kate & Laird, 1999)

8. Future Perspectives and Conclusion

8.1 Future Perspectives

As interest in herbal therapies continues to rise, especially among populations seeking *natural, safer alternatives* to conventional acne treatments, several future directions are worth considering:

- *Standardization and Quality Control*: Future research should focus on the *standardization of herbal formulations* to ensure consistent quality, potency, and reproducibility. Advanced techniques like HPTLC, LC-MS/MS, and NMR can be used to establish phytochemical profiles (Mukherjee et al., 2001).
- *Large-Scale Clinical Trials*: To improve scientific credibility, there is an urgent need for *well-designed, randomized, double-blind clinical trials* with standardized herbal products. These should focus on dose optimization, treatment duration, side-effect profiles, and long-term outcomes (Sharma et al., 2013).
- *Synergistic Herbal Combinations*: Multi-herb formulations with *synergistic mechanisms* (e.g., anti-inflammatory + antibacterial + antioxidant) may enhance treatment efficacy. Integration of traditional Ayurvedic and Unani knowledge with modern pharmacology can optimize such combinations (Agarwal et al., 2020).
- *Integration with Conventional Therapy*: Combining herbal remedies with conventional treatments (e.g., topical antibiotics or retinoids) could offer *integrative approaches* that reduce antibiotic resistance, lower side effects, and improve outcomes (Draeos et al., 2005).
- *Innovative Delivery Systems*: The use of *novel drug delivery systems* such as herbal-loaded nanogels, liposomes, and transdermal patches may improve the *bioavailability, stability, and skin penetration* of phytoconstituents (Pandey et al., 2012).
- *Personalized Herbal Therapy*: With advancements in pharmacogenomics and dermatology, personalized herbal regimens based on *skin type, acne grade, and hormonal profile* may become a reality.

8.2 Conclusion

Herbal remedies for acne present a *promising therapeutic alternative*, offering multi-targeted benefits such as *antibacterial, anti-inflammatory, antioxidant, and sebum-regulating* effects. A wide range of medicinal plants—including *Azadirachta indica*, *Melaleuca alternifolia*, *Curcuma longa*, and *Camellia sinensis*—have demonstrated efficacy through both traditional use and modern research.

However, limitations such as the lack of standardization, inadequate clinical data, and regulatory challenges need to be addressed before herbal products can become mainstream dermatological therapies. Future developments should focus on *scientific validation, clinical testing, formulation innovation, and global regulatory harmonization* to ensure safety, efficacy, and quality.

By combining the wisdom of traditional medicine with the rigor of modern science, herbal treatments have the potential to reshape acne management, particularly in a world that increasingly values *natural, sustainable, and holistic approaches to health*.

REFERENCES :

- Aggarwal, B. B., Sundaram, C., Malani, N., & Ichikawa, H. (2007). Curcumin: the Indian solid gold. *Advances in Experimental Medicine and Biology*, 595, 1–75.
- Agarwal, S., Walia, A., Dhingra, S., & Nagpal, M. (2020). Herbal acne therapy: Current trends and future perspectives. *Journal of Herbal Medicine*, 22, 100344.
- Alyoussef, A. A., Al-Ghamdi, S., Al-Harbi, N. O., & Alghamdi, W. A. (2017). Evaluation of antiacne activity of glycyrrhizin-based herbal gel in acne vulgaris patients. *Journal of Dermatology & Dermatologic Surgery*, 21(2), 66–71.
- Bassett, I. B., Pannowitz, D. L., & Barnetson, R. S. C. (1990). A comparative study of tea-tree oil versus benzoyl peroxide in the treatment of acne. *The Medical Journal of Australia*, 153(8), 455–458.
- Biswas, K., Chattopadhyay, I., Banerjee, R. K., & Bandyopadhyay, U. (2002). Biological activities and medicinal properties of neem (*Azadirachta indica*). *Current Science*, 82(11), 1336–1345.
- Bunyapraphatsara, N., Yongchaiyudha, S., Rungpitarangsi, V., & Chokechaijaroenporn, O. (1996). Antidiabetic activity of Aloe vera L. juice. II. Clinical trial in diabetes mellitus patients in combination with glibenclamide. *Phytomedicine*, 3(3), 245–248.
- Carson, C. F., Hammer, K. A., & Riley, T. V. (2006). Melaleuca alternifolia (Tea Tree) oil: a review of antimicrobial and other medicinal properties. *Clinical Microbiology Reviews*, 19(1), 50–62.
- Chaudhary, H., Dhuna, V., Dhuna, K., Singh, J., & Kamboj, S. S. (2011). Evaluation of hydro-alcoholic extract of *Eclipta alba* for wound healing activity in rats. *Brazilian Journal of Pharmaceutical Sciences*, 47(3), 563–568.
- Chainani-Wu, N. (2003). Safety and anti-inflammatory activity of curcumin: a component of turmeric (*Curcuma longa*). *The Journal of Alternative and Complementary Medicine*, 9(1), 161–168.
- Draelos, Z. D., Carter, E., Maloney, J. M., Elewski, B., Poulin, Y., Kempers, S., & Ling, M. (2005). Two randomized studies of adapalene 0.1% lotion versus gel in the treatment of acne vulgaris. *Cutis*, 76(4), 226–233.
- Hafeez, A., Gan, S. H., & Almajano, M. P. (2014). Polyphenols: Natural antioxidants for prevention of neurodegenerative diseases. *Evidence-Based Complementary and Alternative Medicine*, 2014, 1–7.
- Hammer, K. A., Carson, C. F., & Riley, T. V. (2003). Antifungal effects of Melaleuca alternifolia (tea tree) oil and its components on *Candida albicans*, *Candida glabrata* and *Saccharomyces cerevisiae*. *Journal of Antimicrobial Chemotherapy*, 53(6), 1081–1085.
- Heggers, J. P., Pelley, R. P., & Robson, M. C. (1996). Beneficial effects of Aloe in wound healing. *Phytotherapy Research*, 10(S1), S48–S52.
- Jurenka, J. S. (2009). Anti-inflammatory properties of curcumin, a major constituent of *Curcuma longa*: a review of preclinical and clinical research. *Alternative Medicine Review*, 14(2), 141–153.
- Kim, D. H., Jeong, H. G., & Park, S. Y. (2010). The effect of curcumin on acne-induced inflammation in vivo. *Inflammation Research*, 59(7), 587–595.
- Malhi, H. K., Mehta, A., & Kumari, R. (2020). Synergistic anti-acne potential of polyherbal extract: in vitro and in vivo evaluations. *International Journal of Cosmetic Science*, 42(6), 563–572.
- Mukherjee, P. K., Wahile, A., Kumar, V., & Saha, B. P. (2001). Marker compounds for standardization of botanicals. *Phytomedicine*, 8(4), 347–358.
- Nair, A. B., & Shah, J. (2020). Dermal delivery of drugs: approaches, strategies and evaluation. In *Nanocosmetics and Nanomedicines* (pp. 79–110). Springer.
- Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: an overview. *Journal of Nutritional Science*, 5, e47.
- Pandey, S., Meshya, N., & Viral, D. (2012). Herbs play an important role in the field of cosmetics. *International Journal of PharmTech Research*, 4(1), 309–314.
- Patel, M., & Coogan, M. M. (2012). Antifungal activity of plant essential oils against *Candida albicans* strains isolated from HIV-infected patients. *Journal of Essential Oil Research*, 24(6), 485–490.
- Pattanayak, S., Nayak, S. S., Dinda, S. C., & Panda, D. S. (2012). Anti-acne activity of herbal cream containing turmeric and sandalwood. *International Journal of Pharmaceutical Sciences and Research*, 3(5), 1308–1311.
- Preethi, K. C., Kuttan, G., & Kuttan, R. (2009). Wound healing activity of flower extract of *Calendula officinalis*. *Journal of Basic and Clinical Physiology and Pharmacology*, 20(1), 73–79.
- Rajeswari, R., Umadevi, M., Rahale, C. S., Pushpa, R., Selvavenkadesh, S., Sampath Kumar, K. P., & Bhowmik, D. (2012). Aloe vera: The miracle plant its medicinal and traditional uses in India. *Journal of Pharmacognosy and Phytochemistry*, 1(4), 118–124.
- Sahoo, N., Manchikanti, P., & Dey, S. (2010). Herbal drugs: standards and regulation. *Fitoterapia*, 81(6), 462–471.
- Sharma, S., Khan, I., Ali, I., Ali, F., Kumar, M., Kumar, A., & Ahmad, S. (2013). Evaluation of the antibacterial activity of various extracts of *Eclipta alba* against acne-inducing bacteria. *Asian Pacific Journal of Tropical Biomedicine*, 3(6), 480–483.
- Siddiqui, M. A., Rahman, A., & Ahmad, M. (2018). Antibacterial evaluation of neem (*Azadirachta indica*) leaf extract against acne vulgaris. *Journal of Drug Delivery and Therapeutics*, 8(6), 191–195.
- Surjushe, A., Vasani, R., & Saple, D. G. (2008). Aloe vera: a short review. *Indian Journal of Dermatology*, 53(4), 163–166.
- Ten Kate, K., & Laird, S. A. (1999). *The commercial use of biodiversity: Access to genetic resources and benefit-sharing*. Earthscan Publications.
- World Health Organization. (2004). *WHO guidelines on safety monitoring of herbal medicines in pharmacovigilance systems*. WHO Press.
- Yoon, J. Y., Kim, D. H., Kim, H. S., Kim, M. H., Ko, J. Y., & Park, C. W. (2013). Effects of green tea extracts on acne vulgaris: a randomized, double-blind clinical trial. *Journal of Investigative Dermatology*, 133(S1), S155.