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Herbal Anti-Acne Cosmetics: Phytochemicals, Formulation, Efficacy, Safety and Future Perspectives

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Abstract : *Almost everyone has had a pimple at the worst possible moment, and for millions of people acne is far more than an occasional nuisance. It is one of the most common skin conditions in the world, and more and more people want to treat it with something that comes from a plant and not from a lab. This article looks at what herbal anti-acne cosmetics can and can't do. We start with how acne actually forms, then go through the botanicals that have a believable mechanism or some clinical data, how they end up in gels, serums, face washes and masks, and what safety and regulation mean for the person standing in the shop aisle. Tea tree oil, green tea, aloe, neem and turmeric all show real antiinflammatory, antibacterial or oil-controlling activity, and a few have randomised trials behind them. The evidence is still modest, though, and "natural" is not the same as "harmless". The fairest summary is that herbal products are a sensible helper for mild to moderate acne, not a replacement for medical treatment when acne is serious.*

Keywords: acne vulgaris, herbal cosmetics, cosmeceuticals, tea tree oil, green tea polyphenols, neem, aloe vera, phytochemicals, natural skincare.

I. INTRODUCTION

Acne vulgaris is a long-lasting inflammatory condition of the hair follicle and its oil gland. A global analysis put it at about 9.4% of the world's population, which made it the eighth most common disease on the planet [1]. It usually starts in the teenage years, but many people, especially women, are still dealing with it in their thirties and forties [2]. It is not dangerous, yet it can leave permanent scars, and it often takes a real toll on confidence, mood and day-to-day life.

Standard treatment relies on topical retinoids, benzoyl peroxide, antibiotics and azelaic acid, with oral antibiotics, hormonal therapy or isotretinoin held back for more stubborn disease [4]. These work, but anyone who has used them knows the price: dryness, redness, peeling and sun sensitivity. Long courses of antibiotics also encourage resistant bacteria [5]. It is no surprise that people look for something that feels gentler, more familiar and more sustainable, and plant-based products fit that picture.

Plants are not a new idea here. Ayurveda, Unani, Traditional Chinese Medicine and Persian medicine have all used botanicals for skin eruptions for centuries [7, 28], and researchers are now testing many of those plants for antibacterial, anti-inflammatory, antioxidant and oil-regulating effects [8]. In this article we pull the key points together in one place: the biology of acne, the main plants, how products are made, the safety issues, the rules that apply, and some practical advice.

1.1 Scope and definitions

- **Herbal cosmetic:** a product intended for cleansing, beautifying or altering appearance that uses plant-derived ingredients as its principal actives.
- **Cosmeceutical:** a popular term (not a legal category in most countries) for cosmetics claimed to have drug-

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like benefits.

- **Phytochemical:** a biologically active compound produced by plants, such as flavonoids, terpenes, tannins, alkaloids and polyphenols.

II. UNDERSTANDING ACNE: WHY BOTANICALS ARE TARGETED

To judge any product fairly, you first need to know what it is up against. Four processes work together to produce an acne lesion [3, 13]:

Pathogenic factor	What happens	Possible herbal target
Excess sebum (seborrhoea)	Androgen-driven sebaceous glands produce more lipid, creating a food source for bacteria.	Green tea polyphenols, cannabidiol, zinc-rich or astringent botanicals
Follicular hyperkeratinisation	Dead cells shed abnormally and stick together, blocking the follicle (microcomedone).	Willow-bark salicylates, fruit acids, gentle plant exfoliants
Cutibacterium acnes proliferation	Bacteria colonise the blocked follicle and trigger immune responses.	Tea tree oil, neem, turmeric, basil, clove, thyme
Inflammation and oxidative stress	Cytokines, oxidised sebum lipids and reactive oxygen species produce red papules, pustules and nodules.	Aloe, licorice, chamomile, resveratrol, green tea, curcumin

Table 1. Acne pathogenesis and corresponding botanical targets.

Newer research suggests that inflammation can start before a spot is even visible, and that the particular strains of C. acnes on your skin may matter more than how much of it there is [3]. Diet, stress and even gut health are also being studied as influences [27]. One limit is worth remembering from the start: a herbal cosmetic works on the surface of the skin, so it helps with the local factors but does nothing about hormones.

2.1 Acne severity and where herbal products fit

Grade	Typical presentation	Role of herbal cosmetics
Mild	Mostly comedones, few papules/pustules	Can be used as primary skincare with monitoring
Moderate	Many inflamed papules and pustules, trunk involvement possible	Adjunct to prescribed topicals; may reduce irritation
Severe / nodulocystic	Nodules, cysts, scarring risk	Not a substitute for medical treatment; supportive care only

Table 2. Acne severity and the suitable role of herbal products.

III. KEY HERBAL INGREDIENTS

Reviews of medicinal plants for acne list dozens of species, yet only a handful have ever been tested on people [7, 8]. The sections below walk through the most important ones, starting with those that have the most evidence.

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3.1 Tea tree (Melaleuca alternifolia) oil

Tea tree oil (TTO) is the most thoroughly studied herbal acne ingredient. Its main active, terpinen-4ol, damages bacterial membranes and also dampens inflammation [9]. In one randomised trial, 5% TTO gel and 5% benzoyl peroxide lotion both cleared lesions. The oil was slower, but people had less dryness and burning with it [10]. A later double-blind trial found that 5% TTO gel beat a placebo gel on both lesion count and severity [11].

A word of caution: tea tree oil that has aged and oxidised produces breakdown compounds, including ascaridole and peroxides, that are strong allergens [12]. Good products use fresh oil, add an antioxidant and come in airtight, opaque packaging. Never put the neat oil on your face. Most cosmetic products use 5% or less.

3.2 Green tea (Camellia sinensis)

Green tea is packed with catechins, above all epigallocatechin-3-gallate (EGCG). Lab and clinical work suggests EGCG can tone down the signals that drive oil production, slow the growth of C. acnes and soak up free radicals [14]. In a trial of a 2% green tea lotion, people with mild to moderate acne had meaningful drops in lesion count and severity [13]. The tricky part is keeping it stable. Catechins break down quickly in water and light, so a good product needs antioxidants, a slightly acidic pH and protective packaging.

3.3 Aloe vera (Aloe barbadensis miller)

Aloe gel contains polysaccharides such as acemannan, amino acids, salicylic-acid-like compounds and anthraquinones, which together calm inflammation and help skin heal. In a double-blind trial, people using aloe gel with tretinoin cream did better than those using tretinoin with a placebo gel [15]. So aloe looks more like a useful partner that improves comfort and results than a stand-alone cure. It is also a handy, lightweight moisturiser for skin that is being dried out by stronger treatments.

3.4 Neem (Azadirachta indica)

Neem leaf and seed extracts contain nimbidin, nimbin, azadirachtin, quercetin and other flavonoids, and they show antibacterial, anti-inflammatory and antioxidant effects [16]. You will find neem in countless Indian face washes, face packs and soaps. Most of the proof, however, comes from lab studies, and good human trials of neem on its own are still scarce. The seed oil smells strong and can irritate, which is why leaf extracts are usually preferred in leave-on products.

3.5 Turmeric (Curcuma longa)

Curcumin, the colourful compound in turmeric, switches off NF-κB and other inflammatory pathways and also has antimicrobial and antioxidant activity. A systematic review found turmeric promising for several skin problems, acne included, but pointed out that curcumin barely penetrates skin, breaks down easily and stains everything yellow, so better delivery systems are needed [17].

That is why many brands choose turmeric essential oil or tetrahydrocurcumin, which is colourless and more stable.

3.6 Willow bark (Salix alba) and natural salicylic acid

Willow bark contains salicin, which the body can turn into salicylic acid. Cosmetic extracts, though, usually carry much smaller and less predictable amounts than pure salicylic acid does. The pure betahydroxy acid dissolves in oil, slips into the pore, loosens the plug of dead cells and works well on blackheads and whiteheads [20]. Many "natural" salicylic acid products are made from wintergreen or willow, but the molecule is exactly the same as the synthetic one. So look at the percentage on the label, not the marketing line on the front.

3.7 Other botanicals with supporting data

Botanical	Key constituents	Proposed benefit	Evidence level
Resveratrol (grape, Polygonum)	Stilbene polyphenol	Antibacterial, antiinflammatory, reduces microcomedone area	Small vehiclecontrolled pilot [18]
Cannabidiol (hemp)	Phytocannabinoid	Sebostatic and antiinflammatory effect on human sebocytes	In vitro / early clinical [19]

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Licorice (Glycyrrhiza)	Glabridin, licochalcone A	Anti-inflammatory, soothing, antibacterial	In vitro; some clinical data on irritation [7, 8]
Witch hazel (Hamamelis)	Tannins, proanthocyanidins	Astringent, reduces shine	Traditional; limited acne trials
Holy basil (Ocimum sanctum)	Eugenol, ursolic acid	Antimicrobial, antiinflammatory	In vitro; Ayurvedic use [21]
Manjistha (Rubia cordifolia), sandalwood	Anthraquinones, santalols	Anti-inflammatory, bloodpurifying (traditional)	Ayurvedic formulation trials [21]
Chamomile, calendula	Bisabolol, flavonoids, triterpenes	Soothing, wound-healing	Mainly supportive [22]
Rosemary, thyme, clove	Carnosic acid, thymol, eugenol	Antibacterial in vitro	Laboratory only [23]

Table 3. Additional botanicals investigated for acne and the strength of supporting evidence.

One comparison of Ayurvedic formulations found that several herbal combinations reduced acne lesions in a double-blind, placebo-controlled study [21]. Reviews of complementary therapies, however, warn that many herbal trials are small, short, poorly blinded or badly reported, so any conclusion should be held loosely [6].

3.8 Summary of evidence

Ingredient	Typical use level	Main action	Evidence strength	Main risk
Tea tree oil	2–5% in gels/spot treatments	Antibacterial, antiinflammatory	Moderate (RCTs)	Contact allergy, dryness
Green tea extract	1–2% extract	Antioxidant, sebum modulation	Low to moderate	Instability; rare irritation
Aloe vera	10–70% gel base	Soothing, adjunct	Low to moderate	Rare allergy
Neem	1–5% extract	Antibacterial	Low	Odour, irritation (seed oil)
Turmeric / curcumin	0.5–2% extract	Anti-inflammatory	Low	Staining, sensitisation
Willow bark	Variable	Mild exfoliation	Low (extract); strong for pure SA	Salicylate sensitivity
Resveratrol	0.5–1%	Antioxidant, antibacterial	Low (pilot)	Instability

Table 4. Comparative summary. Use levels are indicative, drawn from typical practice and trial concentrations; follow supplier and regulatory limits.

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IV. MECHANISMS OF ACTION

Herbal ingredients fight acne in five main ways, and the better products usually combine at least two of them:

- **Antibacterial:** terpenes (terpinen-4-ol, thymol), alkaloids and phenolics damage bacterial membranes and interfere with enzyme function. Plant antimicrobials rarely produce the same resistance seen with antibiotics, although data are still developing [9].
- **Anti-inflammatory**: curcumin, licorice flavonoids, bisabolol and EGCG reduce prostaglandins, interleukins and NF- B signalling, calming erythema [14, 17].
- **Sebum regulation:** catechins and cannabidiol modulate sebocyte lipid production and inflammatory response [14, 19].
- **Keratolytic and comedolytic**: salicylates and fruit acids help unplug follicles [20].
- **Antioxidant and anti-scarring:** polyphenols neutralise free radicals and some plant extracts inhibit collagenase and elastase, which may limit tissue breakdown [23].
- **A caveat:** a lot of these findings come from in vitro experiments, where an extract is dropped straight onto bacteria or cells in a dish. On real skin, absorption, stability and the base of the product can change the outcome a great deal.

V. FORMULATION OF HERBAL ANTI-ACNE COSMETICS

A great plant extract can still make a poor product. Formulators have to balance results, skin feel, stability, preservation and cost all at once [24].

5.1 Product forms

Product type	Suitable herbal actives	Notes
Foaming face wash / syrup cleanser	Neem, tea tree, green tea, aloe	Short contact time; low active concentration; avoid harsh sulphate-heavy bases
Toner / astringent	Witch hazel (alcohol-free), green tea, licorice	Choose alcohol-free; check for fragrance allergens
Gel / gel-cream	Tea tree, aloe, resveratrol	Light, non-comedogenic; best vehicle for oily skin
Serum	Green tea, licorice, curcuminoids	Higher active load; needs antioxidants and airless/opaque packaging
Clay mask / pack	Neem, turmeric, sandalwood with kaolin or bentonite	Rinse-off; absorbs oil; risk of overdrying
Spot treatment	Tea tree 5%, salicylates	Apply only to lesions; patch-test first
Soap / bar	Neem, tea tree, charcoal	Alkaline pH can disturb the barrier; syndet bars preferable
Moisturiser / sunscreen	Aloe, chamomile, green tea	Essential for retinoid or drying-agent users; select non-comedogenic

Table 5. Common herbal anti-acne product forms and their formulation considerations.

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5.2 Extraction and standardisation

No two batches of a plant are the same. Species, soil, climate, harvest time and the extraction method all change what ends up in the bottle, and water, ethanol, glycerin and supercritical CO extracts each give a different profile.

To get reliable results, a manufacturer should name the plant and the part used, state the solvent and ratio, and standardise to a marker compound, for example terpinen-4-ol in tea tree oil, EGCG in green tea or curcuminoids in turmeric. Every batch also needs testing for heavy metals, pesticide residues and microbes.

5.3 Delivery technologies

- Liposomes, niosomes and phytosomes: improve skin penetration and stability of polyphenols and curcumin.
- Nanoemulsions and nanostructured lipid carriers: can reduce irritation of essential oils through controlled release.
- Cyclodextrin and polymeric microspheres: protect volatile oils and provide slow release.
- Hydrogel and film-forming systems: provide sustained contact on lesions.

This is a busy area of research [8], but claims should rest on tests on real skin, not just on particle size figures.

5.4 Stability, pH and preservation

Acne-friendly products generally sit at a pH of about 4.5 to 6. Anything containing water is a welcoming home for microbes, so a broad-spectrum preservative is a must. Those "fresh, preservative-free" herbal masks are a real hazard, whatever the label suggests. Essential oils and polyphenols also oxidise, so good formulas include antioxidants such as tocopherol or rosemary extract, chelating agents and light-proof packaging. Accelerated stability tests (for example 40 °C for three months), preservative challenge tests and packaging compatibility checks are standard practice.

5.5 Non-comedogenic design

Acne-prone skin generally prefers light textures. Heavy butters, coconut oil and isopropyl myristate can clog pores in some people, while jojoba, squalane, hemp seed oil and sunflower oil tend to be better tolerated. Oils rich in linoleic acid may even help, because the sebum of people with acne is often short of it. And a "non-comedogenic" label should ideally be backed by testing, not just by a look at the ingredient list.

VI. SAFETY, ADVERSE EFFECTS AND MISCONCEPTIONS

"Natural" is a marketing word, not a safety certificate. A plant extract is a complicated mixture, and some of what is in it can trigger allergies. How your skin reacts depends on the dose, the quality and, of course, on you.

Risk	Examples	Prevention
Allergic contact dermatitis	Oxidised tea tree oil, lavender, ylang-ylang, fragrance allergens (limonene, linalool) [12]	Patch test; fresh oil; declare allergens; avoid unneeded fragrance
Irritant dermatitis	Undiluted essential oils, highconcentration clay masks, alcoholbased toners	Correct dilution; limit mask time; barrier moisturiser
Phototoxicity	Citrus oils (bergamot, lime) containing furocoumarins	Use furocoumarin-free grades; apply at night; daily sunscreen
Contamination	Unpreserved DIY or kitchen-based preparations	Use preserved, tested products; avoid raw ingredients (lemon juice, baking soda, toothpaste)
Adulteration	Hidden steroids or antibiotics in unregulated "herbal" creams	Buy from licensed manufacturers; be wary of overnight miracle claims
Pregnancy / children	Some essential oils and high-dose salicylates	Seek medical advice before use

Table 6. Main safety concerns with herbal anti-acne cosmetics and how to reduce them.

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6.1 Patch-testing procedure

- Apply a small amount of product to the inner forearm or behind the ear.
- Leave for 24–48 hours without washing; watch for redness, itching or swelling.
- If there is no reaction, introduce one new product at a time to the face, starting on alternate days.

VI. REGULATORY AND QUALITY FRAMEWORK

Rules differ from country to country, and whether something counts as a cosmetic or a drug comes down to the claim on the pack. A product that says it treats or cures acne is normally regulated as a drug. One that cleanses, mattifies or helps keep skin clear is a cosmetic.

- **European Union:** Regulation (EC) No 1223/2009 requires a safety assessment by a qualified assessor, a product information file, good manufacturing practice, labelling of ingredients and 26 listed fragrance allergens, and substantiation of claims [25].
- **United States:** The Modernization of Cosmetics Regulation Act of 2022 expanded FDA oversight, including facility registration, product listing, adverse-event reporting and safety substantiation [26].
- **Salicylic acid and benzo**yl peroxide at specified levels are regulated as OTC acne drugs.
- **India:** Cosmetics are governed by the Drugs and Cosmetics Act, 1940 and the Cosmetics Rules, with Bureau of Indian Standards specifications for many product types; products with therapeutic claims fall under drug rules, and AYUSH regulations apply to Ayurvedic formulations.
- **Claims:** Phrases such as "clinically proven", "dermatologically tested" and "100% natural" should be backed by real evidence; "natural" has no uniform legal definition.
- **Good manufacturing practice (ISO 22716),** carefully checked suppliers, a certificate of analysis for every botanical batch and a system to track adverse reactions after launch are what make a herbal brand trustworthy.

VIII. CRITICAL APPRAISAL OF THE CLINICAL EVIDENCE

A Cochrane review of complementary therapies for acne found several randomised trials of herbal and other natural treatments, but rated the evidence as low quality because of small samples, a high risk of bias and inconsistent reporting. It could not say that these approaches work as well as standard treatments [6]. Wider reviews of plants for acne raise the same concerns [7, 8].

8.1 Typical limitations

- Small sample sizes and short follow-up (usually 4–12 weeks).
- Use of crude extracts with unknown or variable composition.
- Lack of vehicle or active comparators; mixed formulas where individual contributions cannot be separated.
- Publication bias toward positive findings and many studies from single centres.
- Few studies in darker skin types or in adult female acne, although both are common.

8.2 What good future research looks like

- Standardised extracts with named marker compounds and batch reporting.
- Randomised, double-blind, vehicle-controlled trials with 12-week endpoints, lesion counts, global assessment and quality-of-life scales.
- Head-to-head studies versus benzoyl peroxide, adapalene or azelaic acid, and trials of herbal products as add-on therapy.
- Skin microbiome profiling and safety follow-up for sensitisation.

IX. PRACTICAL GUIDANCE FOR CONSUMERS

9.1 Sample routine for mild to moderate acne-prone skin

	Step	Example herbal choices
Morning	Gentle cleanse	

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		Neem or green-tea cleanser, pHbalanced
Morning	Treat / calm	Green tea or licorice serum (optional)
Morning	Moisturise	Aloe-based, non-comedogenic gel moisturiser
Morning	Sun protection	Broad-spectrum SPF 30+, oil-free or mineral
Evening	Cleanse (double only if wearing sunscreen or make-up)	Mild cleanser; avoid scrubs
Evening	Targeted treatment	Tea tree 5% spot gel on lesions, or prescribed retinoid
Weekly	Mask 1–2 times	Kaolin clay with neem or sandalwood; 10 minutes maximum

Table 7. Sample herbal-supported skincare routine. Introduce one product at a time.

9.2 Lifestyle factors

- Wash pillowcases and towels frequently; avoid touching or picking lesions.
- Choose non-comedogenic make-up and remove it before sleep.
- High-glycaemic diets and, in some people, skimmed-milk consumption are associated with more acne; evidence supports a balanced, lower-glycaemic diet as an adjunct [27].
- Stress and sleep deprivation can worsen flare-ups.
- Allow 8–12 weeks to judge any new product; stop if irritation develops.

9.3 When to see a dermatologist

- Deep, painful nodules or cysts, or any scarring.
- Acne that does not improve after about 8–12 weeks of consistent care.
- Sudden adult-onset acne with irregular periods, excess hair growth or other hormonal signs.
- Dark marks (post-inflammatory hyperpigmentation) or significant emotional distress.

X. MARKET TRENDS, SUSTAINABILITY AND FUTURE DIRECTIONS

Natural and herbal personal care is among the fastest-growing corners of the cosmetics business. Shoppers read labels, prefer shorter ingredient lists and are curious about traditional knowledge. A few trends stand out:

- **Hybrid formulations:** pairing botanicals with proven actives such as salicylic acid, niacinamide or low-dose retinoids to improve tolerance and effect.
- **Microbiome-friendly products:** prebiotics, postbiotics and selective botanical antimicrobials that spare beneficial skin flora.
- **Biotechnology:** plant cell cultures and fermentation-derived actives that reduce land use and give uniform composition.
- **Sustainable sourcing:** traceable supply chains, fair-trade and responsible wild-harvest; tea tree and neem are cultivated crops, whereas some species (e.g., sandalwood) face over-harvesting.
- **Personalisation:** skin analysis and AI-assisted recommendations, with caution about unsupported claims.
- **Intellectual property and benefit-sharing**: fair use of traditional knowledge under the Nagoya Protocol.

Greenwashing, where the marketing runs well ahead of the science, remains a problem. Clear labels, independent testing and honest claims are what will separate trustworthy brands from the rest.

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XI. CONCLUSION

Herbal anti-acne cosmetics have a real but limited place in acne care. Tea tree, green tea, aloe, neem and turmeric all offer antibacterial, anti-inflammatory or oil-controlling effects that match what goes wrong in acne, and a small number of controlled studies support their use in mild to moderate disease. But the research is held back by small trials, unstandardised extracts and short follow-up, and plants can cause allergy, irritation and contamination just like any other ingredient.

So what is the sensible approach? Choose standardised, properly preserved products, patch-test them, wear sunscreen and keep the rest of your routine simple. If your acne is moderate to severe, or leaves marks, see a dermatologist sooner rather than later. For researchers and manufacturers, the next step is clear: rigorous trials of standardised extracts and honest labels. And for the rest of us, "natural" should be where the questions begin, not where they end.

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