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Nature's Antifungal Shield: Exploring Essential Oils in Polyherbal Soap Development

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ABSTRACT

Superficial fungal infections, including dermatophytosis and cutaneous candidiasis, are common and may recur when treatment is incomplete or predisposing factors persist. Plant-derived essential oils are of research interest because their volatile constituents may act on multiple microbial targets. This review synthesises the supplied literature on a proposed polyherbal cleansing bar containing clove (Syzygium aromaticum) oil, oregano (Origanum vulgare) oil, lemongrass (Cymbopogon citratus) oil and Aloe vera gel. Clove oil is associated mainly with eugenol; oregano oil commonly contains carvacrol and thymol; lemongrass oil is often rich in citral; and Aloe vera gel contains polysaccharides such as acamannan. In-vitro studies report antifungal activity for individual oils and selected combinations. A 2024 study reported additive or synergistic activity for some clove–oregano essential-oil combinations and evaluated an oil-based soap. These findings support further formulation work, but they do not establish clinical effectiveness of the exact four-component bar. A melt-and-pour glycerin base is a practical development platform. Evaluation should include appearance, mass uniformity, pH, foam, moisture, hardness, stability, antifungal activity and skin compatibility. Essential oils can irritate or sensitise skin, and fresh Aloe gel can compromise stability; therefore, concentration optimisation, preservation, controlled laboratory testing and regulatory review are essential. The proposed soap should be regarded as an investigational topical cleansing product, not a replacement for diagnosis or evidence-based antifungal treatment [1–10].

REVIEW HIGHLIGHTS

Individual essential oils and Aloe vera have reported in-vitro antifungal activity, but the exact four-ingredient soap has not been clinically validated.

Clove–oregano combinations showed additive or synergistic potential in one 2024 study; lemongrass and Aloe vera were not validated in that exact bar.

A prototype containing 2% each of clove, oregano and lemongrass oils plus 5% Aloe gel gives 6% total essential oil, which may be irritating or sensitising.

Melt-and-pour glycerin soap is a practical platform, but the finished bar must be tested for pH, foam, hardness, moisture, stability, antifungal activity and skin safety.

Regulatory classification depends on composition, intended use and claims; disease-treatment claims require appropriate evidence and regulatory review

Keywords: Polyherbal soap; clove oil; oregano oil; lemongrass oil; Aloe vera; essential oils; antifungal activity; melt-and-pour; quality control; skin safety.

1. INTRODUCTION

Fungal infections of the skin range from dermatophyte infections of keratinised tissues to cutaneous candidiasis and other superficial mycoses. Warm, humid conditions, sweating, occlusion, barrier disruption and some underlying health conditions can favour infection. Standard topical or systemic antifungal medicines remain the standard of care where indicated. Recurrence may be linked to incomplete treatment, reinfection or persistent predisposing factors [10].

Plant-derived products are being investigated as sources of antimicrobial molecules and as components of personal-care formulations. Essential oils are chemically complex mixtures whose composition varies with plant species, chemotype, geography, harvest stage, extraction and storage. Laboratory activity does not automatically translate to a finished soap because the soap matrix, dilution during washing, contact time, solubility and volatility affect the amount of active material available at the skin surface [4,6,7,10].

This review synthesises the supplied papers on clove, oregano, lemongrass and Aloe vera, with emphasis on the rationale for a combined soap, a melt-and-pour development pathway, evaluation methods, safety, quality and evidence gaps [1–10].

2. ANTIFUNGAL POTENTIAL OF SELECTED INGREDIENTS

2.1 Clove oil (Syzygium aromaticum)

Clove oil is associated principally with eugenol. Chee and Lee reported inhibition of dermatophyte spore germination and mycelial growth by clove oil and its vapour [1]. These findings support antifungal investigation, but they do not establish the performance of clove oil in a wash-off soap. Clove oil is volatile and can cause irritant or allergic contact dermatitis; concentration and storage quality matter [6,7,10].



Figure 1. Clove essential oil with clove buds (image supplied for this manuscript).

2.2 Oregano oil (Origanum vulgare)

Oregano oil commonly contains carvacrol and thymol. Daouk and colleagues reported antifungal activity of Origanum syriacum oil against selected moulds, but species and oil composition limit direct generalisation to commercial oregano oil [2]. Phenolic-rich oregano oil warrants particular care for skin irritation and sensitisation. Cruz and colleagues (2024) are especially relevant because they studied clove and oregano essential oils, combination effects and an oil-based soap [7].



Figure 2. Oregano leaves and essential oil (image supplied for this manuscript).

2.3 Lemongrass oil (Cymbopogon citratus)

Lemongrass oil is often rich in citral, comprising geranial and neral. Boukhatem and colleagues described lemongrass oil activity against selected yeasts and moulds and also studied anti-inflammatory effects in experimental models [5]. Pandey and colleagues characterised lemongrass oil and evaluated antimycotic activity [9]. These studies support biological plausibility, but the exact lemongrass-containing soap requires its own testing.



Figure 3. Lemongrass essential oil and leaves (image supplied for this manuscript).

2.4 Aloe vera gel

Aloe vera gel contains polysaccharides such as acamannan. Aloe studies provide preliminary, concentration-dependent in-vitro findings, but some used plant pathogens rather than human dermatophytes [3]. Aloe-derived ingredients vary by processing and purity. Fresh Aloe gel can also compromise product stability, so a standardised cosmetic-grade ingredient and appropriate preservation are preferable for formulation development [8].



Figure 4. Aloe vera leaf showing the gel-bearing interior (image supplied for this manuscript).

Table 1. Selected ingredients, reported evidence, and formulation considerations.

Ingredient and characteristic constituents	**Reported evidence in the cited literature**	**Formulation relevance**
Clove oil (Syzygium aromaticum); eugenol	Clove oil and vapour inhibited dermatophyte spore germination and mycelial growth in a laboratory study [1].	Volatile oil; standardise source and concentration, and assess oxidation and skin compatibility.
Oregano oil (Origanum vulgare); carvacrol and thymol	Antifungal findings are reported for Origanum oils; species and chemotype differences limit direct transfer [2,7].	Confirm botanical identity and composition; assess irritation and sensitisation.
Lemongrass oil (Cymbopogon citratus); citral	Selected yeast and mould activity has been reported for lemongrass oils [5,9].	Volatility and composition vary; test the finished soap and package stability.
Aloe vera gel; polysaccharides including acemannan	Preliminary concentration-dependent in-vitro findings exist, including studies not limited to human dermatophytes [3,8].	Use a standardised cosmetic-grade ingredient; assess preservation and bar stability.

3. POSSIBLE MECHANISMS OF ANTIFUNGAL ACTION

Essential oils may act through multiple mechanisms, including disruption of fungal membranes, interference with cell-wall or enzyme function, and inhibition of spore germination or mycelial growth. Eugenol, carvacrol, thymol and citral are volatile constituents with reported antimicrobial activity. However, mechanism data from isolated oils do not directly predict activity of a diluted wash-off soap. The soap base, surfactants, water hardness, contact time and rinsing can reduce or alter exposure. Therefore, the proposed complementary activity of clove, oregano, lemongrass and Aloe vera must be confirmed by testing the finished formulation against selected fungal strains [1–10].

4. RATIONALE FOR THE POLYHERBAL COMBINATION

A polyherbal cleansing bar combines several plant-derived ingredients in one dosage form. Clove, oregano and lemongrass oils provide volatile phytochemicals with reported antifungal potential, while Aloe vera gel may support skin comfort and serve as a formulation component. A cleansing bar may help remove sweat, debris and surface contaminants. However, brief wash-off exposure is not equivalent to a validated antifungal medicine left on the skin. Soap alone should not be assumed to eradicate dermatophytes or treat infection. Synergy should not be assumed merely because several ingredients are combined; it must be evaluated experimentally by comparing the finished soap with individual oils, base-only controls and a standard antifungal agent [4,6,7,10].

5. FORMULATION AND EVALUATION

5.1 Melt-and-pour protocol

A documented glycerin melt-and-pour soap base can be used. Materials include authenticated or traceable clove, oregano and lemongrass essential oils with certificates of analysis where available; a standardised cosmetic-grade Aloe vera ingredient; a calibrated balance; thermometer; heat-resistant vessel; stirrer; moulds; protective equipment; and suitable packaging. The general workflow is: clean equipment; weigh and cut the soap base; melt in a controlled water bath or double boiler; cool to the lowest pourable temperature permitted by the supplier; add a pre-weighed essential-oil blend gradually with gentle stirring; add the Aloe ingredient; mix until uniform; pour into moulds; solidify; demould; condition; label and retain samples [4,6].

5.2 Illustrative screening design

A literature-derived prototype can be used as one comparison arm: clove oil 2 g, oregano oil 2 g, lemongrass oil 2 g, Aloe ingredient 5 g, and soap base q.s. to 100 g. This is not a safety recommendation or a final optimised composition. Because the combined essential-oil level is 6% w/w, lower-total-oil batches and single-oil controls should be included. Do not add preservative or antioxidant by assumption; choose only compatible materials at supplier-recommended levels and validate their function. Vitamin E is an antioxidant, not a broad-spectrum preservative [4,6].

Controls should include a base-only control, individual-oil formulations, the combination formulation and, where appropriate, a reference antifungal control for laboratory assays. Prepare independent replicate batches and document actual weights, temperatures, mixing times, appearance, yield and deviations [4,6,7].

5.3 Evaluation parameters

* Organoleptic properties

Record colour, odour, appearance, texture and visible uniformity. Note any oil droplets, sweating, cracking or separation. These observations are simple but important indicators of batch-to-batch consistency.

* pH

Measure pH using a calibrated pH meter on a clearly defined soap solution or dispersion. Report the sample concentration, water used, temperature and method. Do not report a pH value without stating the measurement procedure. The result should be interpreted in relation to the type of soap base and skin compatibility; pH alone does not establish safety.

*Weight variation and physical quality

Weigh individual soap units and calculate the mean and variation. Assess hardness or handling strength using a consistent method. Record moisture or mass loss where appropriate, especially because adding Aloe vera gel can change water content. Use replicate samples and report mean values and variation.

* Foaming and foam stability

Use a standardized cylinder-shake or other validated foam method. Keep soap concentration, water volume, number of shakes, cylinder dimensions and reading times constant. Record initial foam height and foam remaining after a defined interval. Foam performance is a product-quality measure and should not be treated as direct evidence of antifungal efficacy.

*Stability

Observe samples during a defined storage period for changes in colour, odour, hardness, surface sweating, cracking, oil separation, weight and pH. If facilities allow, compare storage under controlled conditions and retain samples in the intended packaging. A short college project can report preliminary stability only; it cannot establish a commercial shelf life without a suitably designed stability programme.

*Antifungal activity

Antifungal testing should use clinically relevant organisms, such as Candida albicans and dermatophytes including Trichophyton rubrum, Trichophyton mentagrophytes or Epidermophyton floccosum, according to biosafety capacity. Use a validated method, positive antifungal control, base-only negative control, solvent/dispersant control and biological replicates. Diffusion assays are affected by solubility and diffusion; therefore, lack of a zone does not always mean lack of activity, and a zone alone does not establish clinical effectiveness [1,3,5,7,9].

Table 2. Suggested evaluation parameters for the finished soap.

Evaluation parameter	Suggested observation or method	Interpretation point
Appearance and uniformity	Colour, odour, texture, visible oil droplets, sweating, cracking, and separation.	Compare replicate batches and record observations.
pH	Measure a defined soap solution or dispersion with a calibrated meter; report concentration and method.	Interpret with measurement method and product use in view.
Mass and physical quality	Unit mass variation, hardness or handling strength, and moisture or mass loss.	Use a consistent method and replicate units.
Foam	Initial foam and foam stability under fixed soap concentration, water volume, and mixing conditions.	Report the procedure and reading times.
Stability	Track colour, odour, hardness, sweating, cracking, separation, mass, and pH during defined storage.	Include packaging and storage conditions.
Antifungal activity	Test relevant fungi with positive, base-only, and dispersant controls and biological replicates.	A diffusion result alone does not establish clinical effectiveness.
Skin compatibility	Review ingredient safety information and evaluate the final composition under appropriate oversight.	Antimicrobial activity does not establish skin safety.

6. BIOLOGICAL SAFETY AND EFFICACY PROFILES

The supplied literature supports in-vitro antifungal activity of selected essential oils and reports a study of clove/oregano oil-based soap. The strength of evidence differs by ingredient, fungal species, formulation and assay. Published inhibition zones or MIC values from separate studies should not be pooled without accounting for methodological differences. A finished soap requires its own testing because the base may change solubility, availability and contact time of the actives [1–10].

Safety must be evaluated independently of antimicrobial activity. Essential oils can cause irritant or allergic contact dermatitis; clove oil and phenolic-rich oregano oil warrant particular care. Oxidised or poorly stored oils may have altered sensitisation potential. Aloe-derived ingredients also vary by processing and purity. Avoid application to eyes, mucosa, broken skin or large body areas unless specifically assessed for that use. Do not assume that a product is safe because it is described as “natural” [6,7,8,10].

Initial assessment should include review of supplier safety data and ingredient limits, appropriate in-vitro compatibility testing where available, and a professionally supervised skin-safety evaluation designed under relevant ethical and regulatory requirements. No claim of “zero irritation”, “safe for sensitive skin” or “clinically proven” should be made without evidence generated for the actual final formulation [6,7,8,10].

7. COMPARATIVE LITERATURE AND EVIDENCE GAPS

Chee and Lee (2007) reported inhibition of dermatophyte spore germination and mycelial growth by clove oil and its vapour [1]. Daouk and colleagues (1995) reported antifungal activity of Origanum syriacum oil against selected moulds [2]. Boukhatem and colleagues (2014) described lemongrass oil activity against selected yeasts and moulds and anti-inflammatory effects in experimental models [5]. Pandey and colleagues (2003) characterised lemongrass oil and evaluated antimycotic activity [9]. Aloe studies provide preliminary, concentration-dependent in-vitro findings, but some used plant pathogens rather than human dermatophytes [3].

Cruz and colleagues (2024) is especially relevant because it investigated essential oils including clove and oregano, combination effects and an oil-based soap [7]. The findings support further product development but do not validate the proposed four-ingredient soap containing lemongrass and Aloe. Lande (2025) describes an herbal antifungal soap with a different ingredient set and reports physicochemical and microbiological testing; it is useful as a formulation precedent rather than direct evidence for this exact combination [6].

Major gaps include: standardised botanical identity and oil chemistry; reproducible formulations and dose–response testing; testing of the finished bar rather than isolated oils only; adequate irritation and sensitisation evaluation; real-time stability and packaging compatibility; head-to-head comparison with appropriate controls; and controlled clinical studies before therapeutic claims. The literature justifies investigation, not a conclusion that the proposed product is already clinically effective [4,6,7,10].

8. REGULATORY GUIDELINES AND QUALITY CONTROL

Regulatory classification depends on the country, composition, intended use and especially the claims made on labels and in advertising. In India, the manufacturer should determine whether the product is regulated as a cosmetic, drug or another category under applicable current laws and rules, and consult the Central Drugs Standard Control Organisation, relevant state licensing authority and qualified regulatory professionals as appropriate. A claim to treat or prevent fungal disease may trigger requirements different from those for an ordinary cleansing cosmetic. International frameworks such as the US FDA and European Union cosmetics or medicinal-product systems are not interchangeable with Indian requirements [4,6,10].

A quality-control plan should include identity and traceability of botanical materials; essential-oil composition or supplier certificate of analysis; microbial quality of raw materials and finished product where applicable; batch records; mass uniformity; appearance and odour; pH by a defined method; hardness; moisture; stability; packaging compatibility; and validated antifungal testing if an antifungal claim is pursued. Set specifications from applicable standards, validated methods and development data. Do not present generic numerical targets as universal regulatory standards unless a relevant standard explicitly requires them [4,6,7].

Good manufacturing practice, hygiene, suitable equipment, documented deviations, complaint handling and adverse-event monitoring should be addressed before scale-up. Product labels should accurately identify ingredients, batch and responsible manufacturer, and should avoid unsupported disease-treatment, “resistance-proof”, “chemical-free” or “non-irritating” claims [4,6,10].

9. ADVANTAGES, LIMITATIONS AND FUTURE SCOPE

A polyherbal antifungal soap may offer convenient cleansing and local delivery of plant-derived phytochemicals. It is easy to use and may be acceptable to patients because of its familiar dosage form. However, essential oils are volatile, can irritate or sensitise skin, and may lose activity during storage. Aloe gel can affect stability, and the soap base and wash-off use can limit contact time. Promising in-vitro activity does not automatically prove clinical effectiveness.

Future work may evaluate nanoemulsions or encapsulation to improve essential-oil dispersion, reduce volatility and support reproducible delivery. Such systems may alter skin exposure and toxicity, so they require new safety and efficacy testing. Other priorities include chemotype-specific oil selection, GC-MS characterisation, standardised Aloe ingredients, lower-dose optimisation, packaging that limits oxidation and volatile loss, and a structured design-of-experiments approach to assess oil ratios and base compatibility [5,7,9,10].

A staged research programme is recommended: (1) authenticate and characterise raw materials; (2) screen individual oils and combinations in vitro; (3) develop multiple low-to-high concentration prototypes within applicable safety limits; (4) test physical properties and short-term compatibility; (5) evaluate antifungal activity of the finished soap with appropriate controls; (6) conduct stability and safety studies; and (7) only if supported, pursue regulatory review and ethically approved clinical studies [4,6,7,10].

10. CONCLUSION

Clove, oregano and lemongrass essential oils, together with Aloe vera gel, provide a scientifically plausible basis for investigating a polyherbal antifungal cleansing bar. The supplied literature reports antifungal activity for several individual ingredients and selected clove–oregano combinations, while a melt-and-pour base offers a convenient formulation route. Nevertheless, the available evidence does not establish clinical efficacy or safety for the exact four-component product. Oil composition, concentration, matrix compatibility, wash-off contact time, stability, irritation and regulatory classification remain critical. The proposed formulation should therefore be treated as a research prototype and evaluated systematically, with results reported transparently and without substituting laboratory findings for clinical evidence or standard antifungal care [1,2,3,5,7–10].

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