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Polyherbal Gel Formulation as a Potential Topical Antifungal Agent

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ABSTRACT :

Superficial fungal infections caused by dermatophytes and Candida species are common and may be associated with recurrence, irritation, and reduced response to conventional antifungal drugs. This has increased interest in plant-derived topical preparations. Neem (Azadirachta indica), tulsi (Ocimum sanctum), and turmeric (Curcuma longa) are medicinal plants with reported antifungal activity. Neem has shown inhibitory effects against dermatophytes and Candida species. Tulsi extracts and essential oil have demonstrated antifungal activity that may be associated with disruption of fungal membrane integrity. Curcumin, the main active constituent of turmeric, has shown anticandidal activity and may affect ergosterol synthesis and fungal virulence factors.

A polyherbal gel containing these three herbs may provide local antifungal action together with anti-inflammatory and antioxidant benefits. Gel formulations are suitable for topical application because they are easy to spread, non-greasy, and can provide local retention of active constituents. Important evaluation parameters include appearance, homogeneity, pH, viscosity, spreadability, extrudability, stability, and in-vitro antifungal activity.

This narrative review synthesizes experimental evidence for neem, tulsi, and turmeric and considers additional studies of herbal gels and hydrogels. A systematic review of tulsi studies and an in-vitro Curcuma study support further antifungal investigation, while related gel studies illustrate useful formulation and safety assessments. The findings remain preliminary: the specific neem-tulsi-turmeric gel has not been clinically validated, and extract standardization, compatibility, stability, skin safety, and comparative antifungal testing are required.

REVIEW HIGHLIGHTS

- Individual antifungal activity is reported for neem, tulsi, and turmeric, but the evidence uses varied extracts and test methods.
- Complementary mechanisms are plausible; synergy or antagonism of the three-herb combination remains to be established.
- Curcumin solubility, tulsi-oil stability, neem composition, and extract–polymer compatibility may affect gel performance.
- Priority studies include standardized extracts, interaction testing, release, stability, and skin-tolerability assessment.

Keywords: polyherbal gel; antifungal activity; neem; tulsi; turmeric; Azadirachta indica; Ocimum sanctum; Curcuma longa.

1. INTRODUCTION

Superficial fungal infections of the skin, hair, and nails are common dermatological conditions caused mainly by dermatophytes and Candida species. Warm and humid climates, poor hygiene, prolonged moisture exposure, and reduced immunity may increase their occurrence. Although conventional topical antifungal drugs such as azoles and allylamines are widely used, treatment failure, recurrence, irritation, high cost, and emerging antifungal resistance remain important concerns [1,2].

Medicinal plants have long been used in traditional systems of medicine for the management of skin disorders and infections. Plant extracts contain bioactive constituents that may inhibit fungal growth through different mechanisms, including disruption of the fungal cell membrane, reduction of ergosterol synthesis, and inhibition of fungal enzymes. Therefore, plant-based topical preparations may offer a useful complementary approach for superficial fungal infections [3].

A polyherbal gel combines more than one herbal extract in a suitable topical base. Such a formulation may improve ease of application, spreadability, patient acceptability, and local delivery of active phytoconstituents. Combining neem, tulsi, and turmeric may provide complementary antifungal effects; however, the formulation must be evaluated for pH, viscosity, homogeneity, spreadability, stability, and in-vitro antifungal activity.

This narrative review synthesizes experimental evidence for neem, tulsi, and turmeric and considers additional studies of herbal gels and hydrogels. A systematic review of tulsi studies and an in-vitro Curcuma study support further antifungal investigation, while related gel studies illustrate useful formulation and safety assessments. The findings remain preliminary: the specific neem-tulsi-turmeric gel has not been clinically validated, and extract standardization, compatibility, stability, skin safety, and comparative antifungal testing are required.

Neem (Azadirachta indica), tulsi (Ocimum sanctum), and turmeric (Curcuma longa) are widely recognized medicinal plants with reported antifungal potential. Neem contains limonoids and other phytoconstituents that have shown activity against Candida species and dermatophytes. Tulsi contains constituents such as eugenol, linalool, and other essential-oil components that may damage fungal cell membranes. Turmeric contains curcumin, which has demonstrated anticandidal activity and may affect ergosterol synthesis and fungal virulence factors [4,6,12].

2. ANTIFUNGAL POTENTIAL OF SELECTED HERBS

2.1 Neem Azadirachta indica

Neem (Azadirachta indica) is an important medicinal plant that has been widely used in traditional medicine for skin disorders, infections, and inflammatory conditions. Different parts of the plant, including leaves, seeds, bark, and seed oil, contain bioactive phytoconstituents such as limonoids, nimbin, salannin, azadiradione, gedunin, flavonoids, and tannins. These compounds are considered responsible for the antimicrobial and antifungal properties of neem [7].

Several laboratory studies have demonstrated the activity of neem against fungi associated with superficial infections. Neem seed and leaf extracts have been tested against dermatophytes such as Trichophyton rubrum, Trichophyton mentagrophytes, and Microsporum nanum. In these studies, neem seed extract showed inhibitory activity and altered the growth pattern of the tested dermatophytes. This supports the possible use of neem in topical preparations intended for fungal skin infections [4].

Neem has also shown activity against Candida species. Studies using different neem seed extracts reported that alcoholic and hexane extracts produced better anticandidal effects than certain aqueous or methanolic preparations. These findings show that the antifungal activity of neem may vary according to the plant part used, extraction method, solvent, and concentration of the extract [5].

The antifungal action of neem may be related to damage to fungal cell structures and the combined effects of multiple phytochemicals. Research on neem seed oil has identified triterpenoid compounds that may contribute to antifungal activity. Interestingly, a mixture of neem-derived compounds demonstrated better activity than some individual purified compounds, suggesting that combined constituents may produce additive or synergistic effects [7].

For a polyherbal topical gel, neem is therefore a suitable ingredient because it has reported activity against both dermatophytes and Candida species. However, standardization of the extract, appropriate concentration selection, stability testing, and evaluation of skin compatibility are necessary before its use in a final topical formulation.



Figure 1. Neem (Azadirachta indica) foliage.

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2.2 Tulsi Ocimum sanctum

Tulsi, scientifically known as Ocimum sanctum or Ocimum tenuiflorum, is a widely used medicinal plant in Ayurveda. The leaves and essential oil of tulsi contain several bioactive constituents, including eugenol, linalool, methyl chavicol, ursolic acid, rosmarinic acid, and flavonoids. These phytochemicals contribute to its reported antimicrobial, anti-inflammatory, antioxidant, and antifungal properties [8].

Studies have shown that tulsi extracts and essential oil can inhibit clinically important fungi. Tulsi leaf extract has been evaluated against dermatophytes

such as Trichophyton, Microsporum, and Epidermophyton species, which are common causes of superficial fungal infections. The observed antifungal activity supports the traditional use of tulsi in conditions related to skin infection and ringworm [9].

Tulsi essential oil has also demonstrated activity against Candida species, including strains with reduced sensitivity to azole antifungal drugs. The essential oil and its main constituents, particularly methyl chavicol and linalool, may affect the fungal cell membrane. Experimental studies have suggested that tulsi oil can increase membrane permeability and reduce ergosterol content. Ergosterol is an important component of the fungal cell membrane; therefore, its reduction can impair fungal growth and survival [6].

The activity of tulsi may differ according to the plant material, extraction solvent, concentration, and fungal strain tested. Essential-oil preparations may contain higher concentrations of volatile compounds, whereas aqueous and alcoholic extracts may contain different groups of phytochemicals. Therefore, the extract type should be selected carefully during formulation development [6,8].

Tulsi is a useful component of a polyherbal antifungal gel because it may provide antifungal action through a mechanism complementary to neem and turmeric. Its combination with other herbal extracts may improve the overall activity of the formulation; however, this proposed synergistic effect must be confirmed by laboratory antifungal testing of the final gel.

A systematic review of in-vitro studies provides a broader summary of tulsi's anticandidal evidence. The review selected eight studies from searches of PubMed and the Cochrane database and reported that each described activity of Ocimum sanctum against Candida, often measured by inhibition zones. Eugenol and linalool were identified as likely contributors, although the underlying mechanism remained uncertain. The review also found that one included study had low risk of bias and seven had moderate risk. Its authors considered the findings insufficient to establish therapeutic efficacy because the evidence was laboratory based and clinical outcomes, adverse effects, and durability had not been resolved [16].

These findings support continued investigation of tulsi as one component of a topical preparation, while placing limits on the strength of the claim. An inhibition zone demonstrates growth suppression under a particular laboratory setup; it does not establish the concentration that can be safely delivered through skin, the duration of exposure needed in a lesion, or clinical cure. Results from different plant parts and extraction procedures also cannot be assumed to represent the same product. Standardized extract composition and broth-based susceptibility measures such as minimum inhibitory concentration and minimum fungicidal concentration would make comparisons more informative than zones alone.



Figure 2. Tulsi (Ocimum tenuiflorum) plant.

Photo by Clintacc (CC0). Source: Wikimedia Commons

2.3 Turmeric Curcuma longa

Turmeric (Curcuma longa) is a medicinal rhizome commonly used as a spice and in traditional medicine. Its principal active constituent is curcumin, a yellow polyphenolic compound. Turmeric also contains other curcuminoids and volatile oils that may contribute to its pharmacological effects. Curcumin

has been reported to possess anti-inflammatory, antioxidant, wound-healing, antimicrobial, and antifungal activities [10].

The antifungal activity of turmeric has been investigated particularly against Candida species. Curcumin has demonstrated inhibitory activity against clinical and standard strains of Candida albicans and Candida glabrata. Its activity may be associated with interference in fungal cell-membrane functions, including a reduction in ergosterol content. Curcumin has also been reported to affect plasma-membrane ATPase activity and reduce proteinase secretion, which may decrease fungal growth and virulence [12].

Although curcumin exhibits antifungal potential, its limited water solubility and low bioavailability can reduce its effectiveness when used alone. This limitation is especially important while developing topical preparations. Incorporating turmeric extract or curcumin into a gel base may improve its local application and retention on the skin. The use of suitable excipients and a well-designed gel system can help provide uniform distribution of the extract and better contact with the affected area [10,11].

Turmeric may also support the topical use of the formulation because of its anti-inflammatory and wound-healing properties. Fungal skin infections can cause itching, redness, irritation, and damage due to scratching. Therefore, turmeric may provide additional benefits beyond direct antifungal activity. However, the concentration of turmeric extract should be optimized, since excessive levels may affect the colour, odour, texture, and acceptability of the final gel [10].

In a polyherbal gel, turmeric can complement the antifungal effects of neem and tulsi. The combination may offer multiple phytochemicals with different possible mechanisms of action. Nevertheless, the antifungal activity of the final neem-tulsi-turmeric gel should be compared with a standard topical antifungal drug through appropriate in-vitro testing.

An in-vitro study published in 2022 adds evidence for turmeric against Candida albicans and Candida tropicalis. It examined a glycolic Curcuma longa extract, curcumin, and antifungal photodynamic therapy using blue light-emitting diodes. The authors reported antifungal effects for the extract, curcumin, and light-activated treatment; the extract at 100 mg/mL and curcumin at 200 micrograms/mL did not show toxicity in the Galleria mellonella model used [17]. These results are relevant to the biological plausibility of turmeric-derived agents, but the photodynamic arm requires a defined light source and exposure and therefore does not directly demonstrate the efficacy of an ordinary skin gel. Galleria mellonella findings also do not substitute for human skin irritation, sensitization, or clinical safety testing.

The study further illustrates why the preparation matters. A glycolic extract, purified curcumin, and a light-activated regimen differ in composition, concentration, and mode of action. Their results should not be combined into a single estimate of turmeric's topical effect. For a neem-tulsi-turmeric gel, the relevant next step is to establish whether the selected turmeric extract remains chemically stable and biologically available in the chosen base, then test the finished formulation without relying on external illumination unless photodynamic use is specifically intended.



Figure 3. Turmeric (Curcuma longa) rhizomes.

Photo by Govind Bhalerao (CC0). Source: Wikimedia Commons

Table 1. Antifungal relevance of neem, tulsi, and turmeric in a polyherbal topical gel.

Herb	Reported antifungal evidence	Formulation relevance
Neem (Azadirachta indica)	Activity against selected dermatophytes and Candida species has been reported [4,5].	Plant part, source, and extraction method can alter composition and activity.

Tulsi (Ocimum sanctum)	Essential oil has shown Candida activity; membrane-related effects have been reported [6,9].	Volatile constituents require attention to retention and storage stability.
Turmeric (Curcuma longa)	Curcumin has reported anticandidal activity; poor water solubility complicates aqueous delivery [10–12].	Solubilization, release, colour, and acceptability need evaluation.

3. POSSIBLE MECHANISMS OF ANTIFUNGAL ACTION

The antifungal activity of medicinal plants may result from multiple phytochemicals acting on fungal cell structures and functions. Fungal cell membranes contain ergosterol, an important sterol required for membrane integrity. Disturbance of the membrane or a reduction in ergosterol can impair fungal growth and survival.

Neem contains limonoids, triterpenoids, flavonoids, and other constituents associated with antimicrobial activity. A mixture of neem-derived triterpenoids has shown antifungal activity, indicating that combined constituents may contribute to additive effects [7].

Tulsi contains volatile constituents, including eugenol, linalool, and methyl chavicol. Tulsi essential oil and its major components have been shown to increase membrane permeability and reduce ergosterol content in Candida isolates [6].

Curcumin may reduce ergosterol content, alter plasma-membrane ATPase activity, and decrease proteinase secretion in Candida species. These effects may reduce fungal growth and virulence [12].

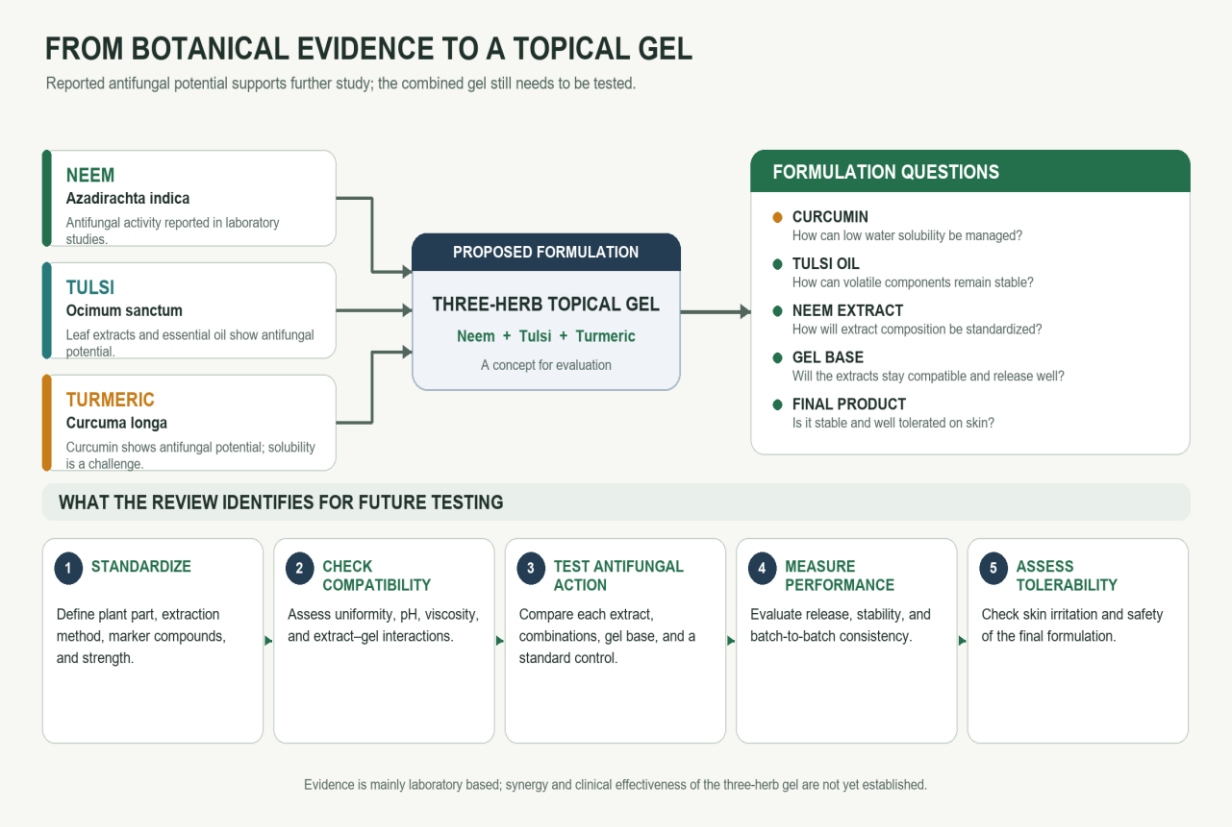
The proposed complementary activity of neem, tulsi, and turmeric should be confirmed by testing the final formulation against selected fungal strains.

4. RATIONALE FOR THE POLYHERBAL COMBINATION

A polyherbal formulation contains two or more medicinal plant extracts in one dosage form. Combining neem, tulsi, and turmeric provides a wider range of phytochemicals with potentially complementary antifungal effects [4, 9, 12].

In addition to antifungal activity, these herbs may offer anti-inflammatory and antioxidant effects relevant to irritated superficial fungal lesions. A gel is a suitable dosage form because it is non-greasy, easily spread, and intended for local delivery.

Synergy should not be assumed merely because three herbs are combined. It must be evaluated experimentally by comparing the final gel with individual extracts and a standard antifungal agent.



5. POLYHERBAL GEL FORMULATION AND EVALUATION

A topical gel is a semisolid preparation in which active ingredients are dispersed in a suitable gel base. Gels are commonly preferred for skin application because they are easy to spread, non-greasy, washable, and generally acceptable to patients. In a polyherbal antifungal gel, standardized extracts of neem, tulsi, and turmeric can be incorporated into a suitable base to provide local action at the affected skin site.

Carbopol 934 or Carbopol 940 is commonly used as a gelling agent in herbal gel formulations. It can produce a clear, smooth, and stable gel with acceptable viscosity. Other excipients may include purified water as a vehicle, glycerin or propylene glycol as a humectant and solvent, methyl paraben or propyl paraben as preservatives, and triethanolamine for pH adjustment. The selection and concentration of all ingredients should be optimized to obtain a stable gel with good skin compatibility [13,14].

In general, the gel can be prepared by dispersing Carbopol in purified water and allowing it to hydrate. The selected neem, tulsi, and turmeric extracts are dissolved or dispersed separately in a suitable solvent system and then added gradually to the hydrated gel base with continuous stirring. Triethanolamine is added carefully to neutralize the Carbopol and obtain the required gel consistency. The final gel should be uniform, free from lumps, and stored in a suitable container.

The prepared polyherbal gel should undergo physicochemical evaluation. Important parameters include colour, odour, appearance, homogeneity, pH, viscosity, spreadability, extrudability, and stability. The pH should be compatible with the skin to reduce the possibility of irritation. Viscosity is important because a gel that is too thin may flow from the application site, whereas a gel that is too thick may be difficult to spread. Spreadability and extrudability indicate whether the gel can be applied comfortably from its container [13,14].

The most important biological assessment is in-vitro antifungal activity. Agar-well diffusion or disc-diffusion methods may be used to evaluate the zone of inhibition against fungal organisms such as Candida albicans, Aspergillus niger, or selected dermatophytes. The activity of the polyherbal gel should be compared with a standard antifungal drug, such as ketoconazole or fluconazole, and with a blank gel base. Stability studies should also be performed to determine whether the gel retains its appearance, pH, viscosity, and antifungal activity during storage [13-15].

Previous polyherbal-gel studies containing neem and tulsi have reported acceptable pH, viscosity, spreadability, and antifungal activity. A formulation study combining neem, tulsi, and fenugreek provides an additional design precedent [13,14,15]. These findings support the feasibility of developing a neem-tulsi-turmeric gel; however, the exact composition and antifungal effectiveness of the proposed formulation must be established through further experimental work.

Table 2. Important evaluation parameters for a polyherbal antifungal gel.

Parameter	**Purpose**
Appearance and homogeneity	Checks colour, texture, and absence of lumps
pH	Ensures compatibility with skin
Viscosity	Assesses gel consistency and ease of use
Spreadability	Measures ease of spreading on skin
Extrudability	Checks ease of removal from the container
Stability	Confirms that the gel remains stable during storage
Antifungal activity	Determines activity against selected fungal species

5.1 Extract compatibility and local delivery

The three botanicals should be treated as distinct raw materials rather than as interchangeable “herbal extracts.” Neem leaves, seed oil, tulsi leaves or essential oil, and turmeric rhizome can yield different chemical profiles. The plant part and extraction solvent determine which constituents are present and at what relative abundance. A formulation record should therefore identify the authenticated species, plant part, source, harvest or procurement details, extraction method, solvent, extract yield, and storage conditions. These details allow another laboratory to reproduce the material and help explain differences between batches. Marker-based testing can further verify that the extracts contain reproducible amounts of selected constituents. For example, curcuminoids may be monitored in turmeric preparations, while volatile constituents should be characterized when essential oils are used. A marker is a quality-control aid; its presence alone does not prove that it is the sole active antifungal compound.

Compatibility has to be examined after the extracts are combined with each other and with the gel base. Curcumin has limited water solubility, and volatile oil constituents can evaporate or oxidize during processing and storage. These properties may affect uniform dispersion, odour, colour, release from the gel, and measured antifungal activity. Solvents and solubilizing excipients can improve dispersion but may also change viscosity, irritate skin,

or influence the assay. The selected gelling agent and neutralizer should produce an acceptable consistency while maintaining a skin-compatible pH. The fenugreek study used sodium alginate, whereas the neem wound hydrogel used guar gum; both examples show that the base is part of the formulation and contributes to its performance [18,19]. Neither base should be assumed to be optimal for the proposed three-herb mixture without comparative testing. Packaging and storage are also relevant to reproducibility. A suitable container should limit contamination and, where required, reduce exposure to light, air, and heat. Stability checks should include visible changes, phase separation, pH, rheology, content of selected chemical markers, and antifungal activity at more than one time point. Accelerated stability can help screen formulations, but a short accelerated study cannot by itself establish a commercial shelf life. Preservative selection should be justified for a water-containing product, and preservative effectiveness and microbial limits should be assessed so that the formulation does not become a source of contamination during repeated use.

5.2 Testing the combined activity of the herbs

The proposed benefit of combining neem, tulsi, and turmeric is that their constituents may affect fungi through different pathways. Neem-derived compounds, tulsi essential-oil constituents, and curcumin have each been associated with antifungal effects in separate studies. This provides a rationale for testing the combination, but it does not show that the effects will add together. One extract may reduce another's solubility, bind to the gel polymer, alter release, or produce irritation at the concentration needed for activity. A mixture may also be less active than a single extract. These possibilities are reasons to treat synergy as an experimental question rather than a property implied by the term "polyherbal."

An appropriate interaction assessment should compare matched concentrations of individual extracts and mixtures against the same fungal isolates. Checkerboard dilution or another validated combination method can estimate whether activity is synergistic, additive, indifferent, or antagonistic under defined conditions. Such results should be confirmed in the finished gel, because the excipients and release profile can change exposure. Controls should include the gel base, solvent controls where relevant, and a standard antifungal drug. Testing more than one clinical isolate and more than one organism group would help determine whether activity is narrow or broad. If the formulation is intended for dermatophyte infections, Candida-only assays are not enough; if it is intended for cutaneous candidiasis, the test panel should reflect that use.

The choice of target also affects the formulation question. Dermatophytes infect keratinized tissues and may require sustained exposure at the stratum corneum or within hair follicles, while Candida may cause infection in moist skin folds and mucosal surfaces. The same topical product may not be suitable for both settings. The review therefore treats "superficial fungal infection" as a broad research area, not as one uniform indication. A future candidate should specify the intended condition, site, patient group, and application schedule before efficacy testing. This prevents an in-vitro result against one species from being generalized to unrelated infections.

5.1 Challenges in translating herbal extracts into topical products

Laboratory antifungal activity does not by itself ensure that an extract will remain stable, be released from a gel, reach the relevant skin layer, or be tolerated during repeated use. Formulation therefore has to address the chemistry of each extract as well as the properties of the gel base.

Curcumin, a major turmeric constituent, has poor aqueous solubility and can show limited availability in simple water-based gels. Its incorporation may require an appropriate solvent, dispersion, emulsion, complexation, or carrier system. The choice should be assessed for compatibility with the polymer and other excipients, uniformity, chemical stability, and effects on release; improving apparent solubility does not automatically establish useful skin delivery [11,21].

Tulsi essential oil contains volatile constituents. Loss during processing or storage, together with changes associated with exposure to light, heat, and oxygen, may alter the amount and profile of oil remaining in the product. Closed, light-protective packaging and stability testing of relevant volatile markers may therefore be considered, while ensuring that the selected approach is compatible with the intended dosage form [6,22].

Neem extracts can vary with plant part, provenance, harvest, storage, and extraction conditions. Botanical authentication and a reproducible extraction method should be paired with marker-based or chromatographic characterization so that batches can be compared. A single species name or total extract percentage is not enough to guarantee consistent phytochemical content [7,23].

Extract–polymer compatibility also requires direct evaluation. Extracts may change gel pH or viscosity, precipitate, separate, or interfere with uniform distribution. Release and skin penetration should be measured for the finished formulation, because results from free extracts cannot predict how the gel base will affect delivery. Colour and odour, especially the strong colour of turmeric and characteristic odour of neem or essential oils, may affect appearance and patient acceptability; these should be documented alongside physical stability and tolerability.

6. EVIDENCE FROM RELATED HERBAL GEL STUDIES

The supplied formulation papers offer practical examples of how plant extracts can be incorporated into semisolid preparations and evaluated. They involve different plants, organisms, anatomical sites, or therapeutic aims, so they are best used as formulation precedents rather than direct proof for the proposed combination. Together, they show the value of measuring both product properties and biological activity, and of reporting safety and stability

alongside an inhibition result.

6.1 Fenugreek gel as a model for cutaneous antifungal development

Kulkarni and colleagues studied aqueous and ethanolic fenugreek leaf extracts against Malassezia furfur, including a clinical isolate and a commercial strain. They also reported activity against Candida albicans and Aspergillus niger. The investigators developed a gel containing 30% aqueous fenugreek extract with sodium alginate as the gelling agent. The preparation retained activity against M. furfur during three months of accelerated stability testing and did not produce irritation or sensitization in New Zealand rabbits under the study conditions [18]. This paper is particularly useful as a development model because it links an antifungal test to an actual gel, short-term stability assessment, and a cutaneous tolerability evaluation. It does not establish that neem, tulsi, or turmeric will behave similarly: fenugreek has a different chemical profile, the target organism is associated with dandruff and seborrheic conditions, and accelerated stability over three months is not equivalent to a full shelf-life study or a human trial.

6.2 Neem hydrogel and wound-healing evidence

A 2023 study developed neem hydrogels with guar gum, with one formulation also containing silk fibroin, to investigate wound healing. The formulations were evaluated for pH, rheology, spreadability, drug content, antimicrobial activity, skin irritation, stability, and in-vivo wound healing. Reported pH values were approximately 5.8, and the authors found no skin irritation in their model; the silk-fibroin-containing hydrogel improved wound repair compared with the control and neem-only groups [19]. This study shows that neem can be incorporated into a topical hydrogel and that formulation performance can be examined alongside biological outcomes. Its primary endpoint was wound healing, not treatment of a fungal skin infection. The additional silk fibroin and the wound model also make its results unsuitable as evidence of antifungal efficacy for a neem-tulsi-turmeric gel. Its contribution is therefore limited to formulation feasibility and a useful set of evaluation methods.

6.3 Essential-oil gel against oral Candida

Jayasankar and colleagues formulated a gel containing Origanum vulgare and Syzygium aromaticum essential oils and evaluated it against oral Candida albicans [20]. This study provides a second example of combining plant-derived antifungal agents in a gel and testing the formulation against a defined fungal target. Its clinical context is oral candidiasis, however, and oral mucosa differs from keratinized skin in permeability, exposure, local environment, and tolerability requirements. Oregano and clove essential oils also differ from neem, tulsi, and turmeric extracts. The paper supports the feasibility of studying a combined herbal gel, but it cannot validate the efficacy, safety, or optimal ratios of the three herbs considered in this review. For the proposed formulation, synergy should be demonstrated with its own extracts and target organisms rather than inferred from another plant combination.

6.4 Implications for the Proposed Neem Tulsi Turmeric Gel

Taken together, these studies suggest a staged formulation strategy. First, each extract should be defined by plant part, extraction solvent, processing conditions, and one or more marker constituents. Extracts should be incorporated into the gel in a way that preserves uniformity and avoids precipitation, phase separation, or loss of volatile constituents. Because curcumin is poorly water soluble and essential-oil constituents can be volatile, the solvent and excipient system must be selected with both solubility and skin compatibility in mind. The finished product, rather than only the free extracts, should be assessed for antifungal activity.

A rational comparison would include the gel base alone, each herbal extract alone, relevant two-extract combinations, the full three-extract formulation, and a standard topical antifungal comparator. This design can determine whether the combination adds activity beyond the individual ingredients and can identify antagonism or reduced availability caused by mixing. Concentration-response testing should accompany inhibition zones, since zones are influenced by diffusion through agar and may favor soluble constituents. Where feasible, minimum inhibitory and fungicidal concentrations, time-kill behavior, and testing against clinically relevant dermatophytes and Candida isolates would provide a stronger picture of activity.

The product should also be assessed for pH, appearance, homogeneity, viscosity or rheological behavior, spreadability, extrudability, and content uniformity. pH near the skin's tolerated range is helpful, but an acceptable pH alone does not establish safety. Preservative effectiveness and microbial quality are important for a water-containing gel. Stability testing should monitor the physical properties and marker content as well as antifungal potency, under both accelerated and longer-term storage conditions. Light and temperature protection may be important for curcumin and volatile oils. The fenugreek and neem hydrogel studies illustrate the value of linking these measurements to biological testing rather than treating a satisfactory texture as evidence of therapeutic performance [18,19].

Finally, tolerability needs to be evaluated on the final composition. Individual extracts may be tolerated separately but cause irritation or sensitization when combined or delivered at a higher concentration. Appropriate skin compatibility testing should precede clinical use, and animal data should be interpreted within their specific model rather than generalized to people. A formulation that performs well in a plate assay may still fail to release its

constituents from the base, penetrate the affected skin layer, or remain on the lesion for a sufficient period. These are formulation questions that can be answered experimentally and should guide candidate selection before any therapeutic claim is made.

7. STANDARDIZATION AND QUALITY CONTROL

Standardization is essential in herbal formulation development because the composition and activity of plant extracts may vary with plant source, season, harvesting method, storage, and extraction procedure. For a neem-tulsi-turmeric polyherbal gel, the selected plant materials should be properly identified, authenticated, dried, and extracted using a suitable standardized method. The final extracts should be evaluated for basic phytochemical constituents and, where possible, marker compounds such as curcumin in turmeric.

Quality-control testing of the prepared gel is also necessary to ensure uniformity, safety, and stability. The formulation should be checked for appearance, homogeneity, pH, viscosity, spreadability, extrudability, and microbial quality. The herbal extracts should be uniformly distributed throughout the gel so that each application provides a consistent amount of active constituents.

Stability testing under suitable storage conditions is important because changes in temperature, light, and moisture may affect the colour, odour, pH, viscosity, and antifungal activity of the formulation. Proper standardization and quality control can improve the reproducibility, safety, and therapeutic reliability of a polyherbal topical antifungal gel.

8. INTERPRETATION OF THE AVAILABLE EVIDENCE

The evidence assembled here spans several distinct levels. Studies of neem, tulsi, and turmeric report antifungal activity in laboratory systems, and the supplied tulsi systematic review summarizes eight in-vitro studies. The 2022 turmeric paper adds tests against two Candida species and an invertebrate toxicity model. Separate formulation studies show that herbal gels or hydrogels can be prepared and evaluated for stability, tolerability, antimicrobial activity, or wound repair. These strands support the rationale for further formulation research, but they do not amount to evidence that the specific neem-tulsi-turmeric gel is effective in patients.

The closest direct evidence should be weighted most heavily. Results from the three named herbs and the target fungal species are more relevant to the central question than studies of unrelated herbs or a different disease site. The fenugreek gel against M. furfur is useful for methods and dosage-form precedent, while the neem-silk fibroin hydrogel informs topical characterization and wound-healing potential. The oregano-clove oral gel demonstrates a way to test a combination but does not establish skin activity. Likewise, the Curcuma photodynamic study is supportive of antifungal potential but its light-activated treatment is not equivalent to passive topical delivery. Keeping these distinctions explicit prevents formulation analogies from being mistaken for direct efficacy evidence.

Interpretation is further limited by variation in botanical materials and laboratory methods. A species name alone does not specify the plant part, chemotype, harvest conditions, extraction solvent, or concentration of active markers. Assay medium, inoculum, incubation time, and fungal strain can affect measured activity. A zone of inhibition can be small when an active constituent diffuses poorly even if it has activity in a broth assay, or can appear large because a compound diffuses readily. Comparing results across studies therefore requires attention to the assay and formulation details, not just the numerical zone.

The review also has a defined scope limitation: it is a narrative synthesis of selected references and the papers supplied for this draft, not an exhaustive systematic search. The source set contains laboratory and formulation studies and includes duplicate copies of one Curcuma article. The available papers do not provide a clinical trial of the exact neem-tulsi-turmeric gel. These limitations mean the review can identify a plausible research direction and development requirements, but it cannot estimate clinical benefit, compare cure rates, or recommend the gel as a replacement for established antifungal treatment.

9. ADVANTAGES, LIMITATIONS, AND FUTURE SCOPE

Polyherbal antifungal gels may offer several advantages for the topical management of superficial fungal infections. They can provide local delivery of plant-derived phytochemicals, are generally easy to apply, and may be more acceptable to patients because of their non-greasy nature. The combination of neem, tulsi, and turmeric may provide antifungal activity along with anti-inflammatory and antioxidant effects. A gel dosage form may also improve contact of the extracts with the affected skin area.

However, herbal formulations have important limitations. The chemical composition of plant extracts can vary according to plant source, season, extraction method, and storage conditions. This variation can affect the consistency of antifungal activity. The solubility and stability of curcumin, possible skin sensitivity, interactions among herbal constituents, and microbial contamination of the formulation should also be considered. Importantly, promising in-vitro activity does not automatically prove clinical effectiveness in patients.

Future research should proceed from product definition to biological and clinical validation. Botanical authentication and reproducible extraction should

be followed by marker-based standardization and compatibility testing in the gel base. The individual extracts and combinations should then be compared across concentration ranges against appropriate fungal strains, a base control, and a standard antifungal comparator. Studies should assess release or retention of active markers, gel stability, preservative effectiveness, skin irritation, and sensitization. A promising formulation should be tested in a relevant preclinical model before a controlled clinical study evaluates safety and outcomes such as lesion clearance, symptom relief, recurrence, and adherence. These stages are needed to establish whether the proposed combination offers a measurable advantage, and should be completed before making claims about synergy, resistance prevention, or clinical effectiveness.

9.1 Research gap and novelty

Individual antifungal properties of neem, tulsi, and turmeric have been reported, and topical neem–turmeric nanoemulgel development has also been described [21]. However, the available evidence does not establish the antifungal interaction, optimal concentration ratio, release behavior, or skin tolerability of a standardized gel containing all three herbs. This gap should be stated specifically for the three-herb combination, rather than implying that topical combinations of these plants have not previously been studied.

The research novelty proposed here is an integrated evaluation of a standardized neem–tulsi–turmeric topical gel: defining the extracts, testing compatibility and concentration ratios, determining whether antifungal effects are synergistic, additive, indifferent, or antagonistic, and relating activity to release, stability, and skin tolerability. These are proposed research questions, not established advantages of the combination. A direct comparison with individual extracts, relevant two-extract mixtures, the gel base, and a standard antifungal comparator would help determine whether the three-herb formulation offers a measurable benefit.

9.2 Proposed formulation development pathway

The following conceptual workflow summarizes a possible development sequence based on the literature. It is included as a proposed framework for future studies; it does not represent procedures performed in this narrative review.

Botanical authentication → Extraction → Standardization → Compatibility → Gel preparation → Evaluation

Figure 4. Proposed workflow for development and evaluation of a standardized polyherbal topical gel.

10. CONCLUSION

Neem, tulsi, and turmeric each have experimental evidence that supports further study as sources of topical antifungal constituents. The supplied literature adds in-vitro evidence for tulsi against Candida, activity of Curcuma longa extract and curcumin against Candida species, and examples of herbal gel and hydrogel development. These findings provide a rationale for investigating a neem-tulsi-turmeric formulation, but the studies differ in plant material, fungal target, route, and outcome.

A topical gel could offer convenient local application, provided that the extracts remain stable, are distributed uniformly, and are released at concentrations that inhibit the target fungi without unacceptable irritation. Related herbal gel studies help identify useful formulation and evaluation methods; they do not establish efficacy of this particular three-herb combination.

The neem-tulsi-turmeric gel should therefore be regarded as a research candidate rather than an established treatment. Standardized extracts, comparative antifungal testing of the final gel, stability and safety studies, and subsequent clinical evaluation are required to determine its quality and therapeutic value.

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