



Polyherbal Medicated Nail Paint for the Treatment of Onychomycosis: A Comprehensive Review

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Abstract—Onychomycosis is a chronic fungal infection of the nail apparatus that significantly affects patient quality of life, accounting for approximately 50% of all nail disorders. Although systemic antifungal agents demonstrate high efficacy, their long treatment duration, potential for hepatotoxicity, and drug inter- actions limit patient compliance. Conventional topical therapies often fail due to the formidable barrier properties of the kera- tinized nail plate. This review investigates the formulation and evaluation of a novel Polyherbal Medicated Nail Paint designed to overcome these limitations. The formulation integrates synergistic herbal agents—Tea Tree Oil, Neem Oil, Garlic Oil, Rosemary Oil, and Bixin—into a volatile lacquer base. This paper details the anatomy of the nail unit, the pathophysiology of fungal, bacterial, and candidal infections, and the pharmacological rationale for each herbal constituent. Furthermore, it presents a comparative formulation matrix for cosmetic versus therapeutic applications and outlines critical evaluation parameters for quality assurance [1], [2].

Index Terms—Onychomycosis, Polyherbal formulation, Med- icated nail paint, Antifungal therapy, Essential oils, Phy- tomedicine.

I. INTRODUCTION

Onychomycosis is a persistent fungal infection of the finger- nails and toenails caused primarily by dermatophytes such as *Trichophyton rubrum*, yeasts like *Candida albicans*, and non- dermatophyte molds. The disease manifests as discoloration, nail thickening (hyperkeratosis), subungual debris accumulation, brittleness, and onycholysis (separation of the nail plate from the bed) [1]. Global prevalence is estimated at 5–12%, increasing with age and comorbidities such as diabetes and peripheral vascular disease.

Current therapeutic strategies are often inadequate. Systemic antifungals (e.g., Terbinafine, Itraconazole) are effective but are associated with severe side effects including liver toxicity and gastrointestinal distress, requiring treatment durations of 3 to 6 months. Conventional topical treatments (creams, ointments) are generally ineffective because they cannot penetrate the dense, hydrophilic keratin structure of the nail plate [2].

Medicated nail paints (lacquers) offer a viable solution by forming an occlusive, adherent film on the nail surface. This film acts as a drug reservoir, releasing antifungal agents continuously into the nail plate over extended periods. The incorporation of herbal essential oils provides a multi-targeted approach, leveraging natural antifungal, antibacterial, and antioxidant properties to combat infection while minimizing resistance and toxicity [3].

I. ANATOMY AND PHYSIOLOGY OF THE NAIL UNIT

A thorough understanding of the nail apparatus is essential for designing effective transungual drug delivery systems. The nail unit is a complex structure comprising several distinct parts.



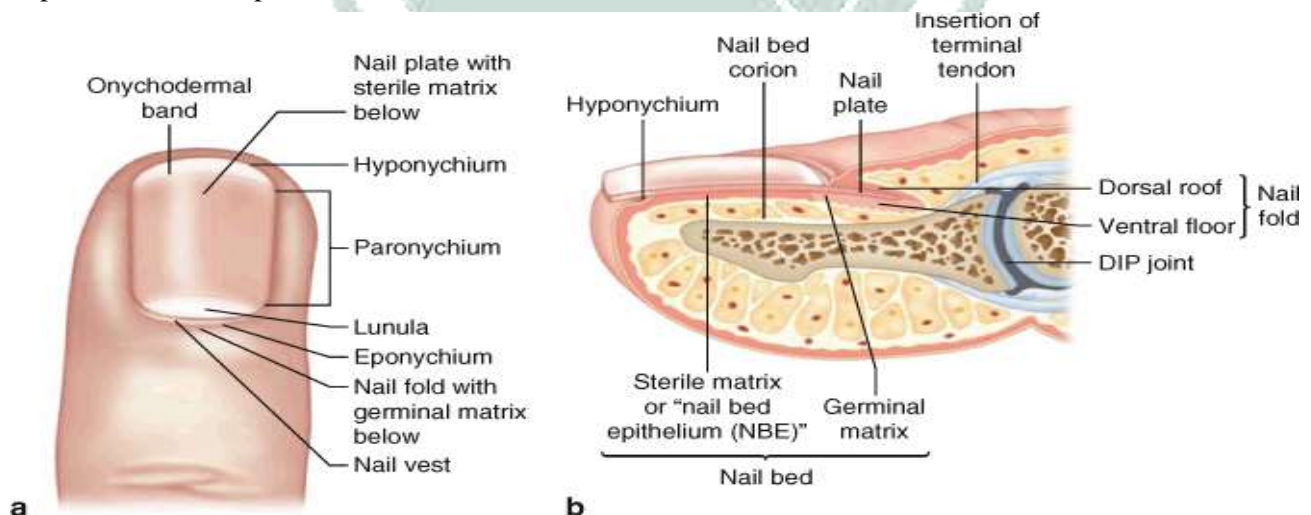
Fig. 1: Anatomy of the nail unit showing the Nail Plate, Matrix, and surrounding tissues.

A. Nail Plate

The nail plate is the hard, visible, keratinized structure composed of dense onychocytes arranged in a lamellar pattern. It is mechanically durable and serves as the primary barrier to drug penetration. The plate is supported by the nail bed and is bordered by the proximal and lateral nail folds [1].

B. Nail Matrix

Located beneath the proximal nail fold, the matrix is the germinal "root" of the nail. It contains melanocytes and is responsible for the production of the nail plate cells. The lunula, the visible white crescent at the base of the nail, represents the distal portion of the matrix.



C. Nail Bed and Hyponychium

The nail bed is the vascular tissue beneath the nail plate that provides nourishment. Unlike normal skin, it lacks a stratum corneum, which allows for better drug absorption if the nail plate barrier is breached. The hyponychium is the seal located under the free edge of the nail, protecting the nail bed from distal pathogen invasion.

II. PATHOPHYSIOLOGY OF NAIL INFECTIONS

Nail infections are categorized by the causative organism and the site of invasion. This formulation targets mixed infections often seen in clinical practice.

Fig. 3: Clinical presentation of Distal Lateral Subungual Onychomycosis (DLSO).



A. Fungal Infections (Onychomycosis)

- **Distal Lateral Subungual Onychomycosis (DLSO):** The most common form, where fungi invade the hyponychium and spread proximally [1].
- **Superficial White Onychomycosis (SWO):** Characterized by "chalky" white patches on the dorsal nail surface.
- **Proximal Subungual Onychomycosis (PSO):** Infection begins at the cuticle, often indicating an immunocompromised state.

B. Bacterial and Yeast Infections

- **Paronychia:** Bacterial infection of the nail folds causing redness, swelling, and pus. It is often acute (trauma-induced) or chronic (moisture-induced).



Fig. 4: Advanced fungal infection showing severe thickening and discoloration.

- **Candidal Onychomycosis:** Caused by *Candida* species, primarily affecting fingernails. It leads to painful swelling of the nail folds and potential nail plate separation.
- **Green Nail Syndrome:** A bacterial infection by *Pseudomonas*, characterized by greenish discoloration due to pyocyanin pigment production.

III. RATIONALE FOR POLYHERBAL FORMULATION

The proposed medicated nail paint utilizes a specific blend of essential oils and natural extracts. The selection is based on their synergistic antimicrobial mechanisms.

A. Tea Tree Oil (*Melaleuca alternifolia*)

Contains Terpinen-4-ol and α -terpineol. It causes extensive disruption of fungal cell membranes and inhibition of respiration. Clinical studies have shown cure rates up to 78.5% in onychomycosis patients [4].

B. Neem Oil (*Azadirachta indica*)

Rich in Azadirachtin, Nimbidin, and Quercetin. It possesses broad-spectrum antifungal activity and significant anti-inflammatory properties, which help soothe the inflamed nail bed during treatment [5], [6].

C. Garlic Oil (*Allium sativum*)

Contains sulfur compounds, primarily Allicin. Allicin inhibits key enzymes in fungal metabolism (e.g., succinate dehydrogenase). Garlic oil also improves local circulation to the nail bed, promoting healthy nail regeneration [7], [8].

D. Rosemary Oil (*Rosmarinus officinalis*)

Contains Rosmarinic acid, camphor, and 1,8-cineole. Apart from antimicrobial action, it acts as a natural **permeation enhancer**, facilitating the transport of other active ingredients through the dense keratin matrix [9].

E. Bixin (*Bixa orellana*)

A natural carotenoid derived from Annatto seeds. It serves a dual purpose: acting as a safe, natural yellow-orange colorant for the cosmetic appeal of the formulation, and providing potent antioxidant protection against UV radiation [10].

CONCLUSION

Polyherbal medicated nail paints represent a promising, safe, and effective alternative for the management of onychomycosis. By combining the therapeutic potency of Neem, Tea Tree, and Garlic oils with the cosmetic appeal of a nail lacquer, this formulation addresses the major barriers to treatment success: toxicity and patient non-compliance. The distinct formulations for cosmetic and therapeutic use demonstrate a patient-centric approach to pharmaceutical design. Further clinical trials are warranted to validate the long-term efficacy and commercial potential of this novel delivery system.

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