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FORMULATION AND EVALUATION OF ANTIFUNGAL LOTION USING TEA TREE OIL AND LEMONGRASS EXTRACT

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Abstract:

The present study focuses on the formulation and evaluation of a herbal antifungal lotion incorporating Tea Tree Oil (Melaleuca alternifolia) and Lemongrass Oil (Cymbopogon citratus), both known for their potent antimicrobial and antifungal activities. The objective was to develop a safe, effective, and skin-friendly topical preparation to combat superficial fungal infections. An oil-in-water (O/W) emulsion type lotion was prepared using standard emulsification techniques, with varying concentrations of the essential oils to identify the optimal formulation. The developed formulations were subjected to physicochemical evaluations such as ph, viscosity, spreadability, homogeneity, and stability studies, along with antifungal activity testing against Candida albicans and Aspergillus niger using the agar well diffusion method. Among the batches (F1–F3), formulation F2 exhibited ideal physicochemical properties, a skin-compatible ph (6–7), superior spreadability, and the highest antifungal efficacy. The results confirm the synergistic antifungal potential of Tea Tree and Lemongrass oils, offering a promising natural alternative to synthetic antifungal agents with fewer side effects. The study concludes that the optimized formulation can serve as an effective, stable, and eco-friendly topical therapy for the management of superficial fungal infections.

Keywords: *Antifungal lotion, Tea Tree Oil, Lemongrass Oil, Herbal formulation, Oil-in-water emulsion, Topical therapy.*

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INTRODUCTION:

Fungal infections of the skin are among the most common dermatological problems worldwide. They can affect all age groups and are mainly caused by dermatophytes such as Trichophyton, Microsporum and Epidermophyton species, as well as yeasts like Candida albicans. Warm and humid climatic conditions, poor hygiene, immunosuppression and frequent use of antibiotics or corticosteroids predispose individuals to such infections. Topical antifungal therapy remains the treatment of choice for superficial infections because it allows localized delivery of the active ingredient, high concentration at the site of infection, and minimal systemic side effects. Consequently, researchers and formulators have shown renewed interest in herbal and essential oil–based antifungal products as potential complementary or alternative therapies. (1)

1.1 Natural Products in Antifungal Therapy

Plants produce a diverse range of secondary metabolites such as terpenoids, alkaloids, phenolics and flavonoids that serve as natural defense mechanisms against microorganisms. Essential oils being concentrated hydrophobic liquids containing volatile aromatic compounds, have been recognized for their broad-spectrum antimicrobial and antifungal activities.Among them, Tea Tree Oil (TTO) and Lemongrass Oil (LGO) have received considerable attention for their strong antifungal efficacy and potential use in topical pharmaceutical formulations. (2)

1.2 Rationale for Combination and Lotion Formulation

Combining tea tree oil and lemongrass extract in a single formulation may provide synergistic antifungal activity due to their complementary mechanisms of action and diverse active constituents. A lotion is a semiliquid topical dosage form, generally an oil-in-water (o/w) or water-in-oil (w/o) emulsion, designed for easy spreadability and absorption. Lotions are especially suitable for hairy or large body areas where creams or ointments may be inconvenient to apply. . Incorporating essential oils into a lotion base provides advantages such as stabilization of volatile components, controlled release and uniform dispersion. It also facilitates the addition of other excipients—such as emulsifiers, humectants, and preservatives—that improve the product's physicochemical stability and shelf life. (3)

1.3 Pharmaceutical and Analytical Evaluation Parameters

The development of an effective antifungal lotion involves both formulation and comprehensive evaluation. The evaluation phase includes:

- Physicochemical tests
- Physical evaluation
- Microbiological studies
- Stability studies
- Stability testing

Such investigations ensure the formulation meets quality, safety and efficacy standards necessary for potential clinical or commercial application. (4)

Fig. No. 1: Anti-Fungal

2. FUNGAL SYMPTOMS AND CAUSES

Symptoms and Causes

Symptoms

- Itching and redness
- Scaling or peeling of skin
- Burning or irritation
- White patches or discoloration
- Cracked or thickened skin/nails

Causes:

- Infection by fungi (Candida, Trichophyton, Microsporum)
- Poor hygiene or excessive sweating
- Humid or warm environment
- Low immunity or diabetes
- Prolonged use of antibiotics or steroids

3 . OBJECTIVE

3.1. Extraction objectives

1. To extract tea tree oil efficiently from melaleuca alternifolia leaves.
2. To obtain lemongrass extract (cymbopogon citratus) using standardized methods.

3.2. Evaluation objectives

1. To assess physical properties: color, odor and appearance.
2. To measure ph and ensure skin compatibility.
3. To determine viscosity and spreadability for easy application

3.3. Quality control objectives

1. To ensure batch-to-batch uniformity of the lotion.
2. To confirm concentration of active ingredients in final formulation.

3.4. Research and development objectives

1. To formulate a novel antifungal lotion using natural extracts.
2. To study synergistic effects of tea tree oil and lemongrass.

4. ADVANTAGES AND DISADVANTAGES

Advantages

1. Natural plant-based ingredients, safer than synthetic drugs.
2. Broad-spectrum antifungal activity against Candida, Trichophyton and Microsporum.
3. Anti-inflammatory properties reduce redness and itching.
4. Antioxidant effects protect skin from oxidative stress.
5. Generally well-tolerated, with fewer side effects.

Disadvantages

1. Risk of allergic reactions or skin irritation in some users.
2. Variability in oil composition depending on source and season.
3. Stability issues under heat, light and air exposure.
4. Shorter shelf life than synthetic formulations.
5. Lower potency in severe or systemic fungal infections.

5. RATIONALE USING HERBAL INGREDIENTS

5.1. The Need for Herbal Alternatives

Fungal infections of the skin such as dermatophytosis, candidiasis and pityriasis versicolor are among the most common dermatological problems worldwide. Although several synthetic antifungal agents are available, long-term use often leads to drug resistance, side effects and recurrence. In contrast, herbal formulations represent a promising alternative because they are biocompatible, biodegradable and derived from renewable resources.(5)

5.2. Tea Tree Oil

Source and Extraction:

Tea Tree Oil is obtained by steam distillation of the leaves and terminal branches of Melaleuca alternifolia, a small tree native to Australia. The distillation process yields a pale yellow, aromatic oil with a characteristic camphoraceous odor.

Chemical Composition and Active Principle:

The key constituents include terpinen-4-ol, γ-terpinene, α-terpinene, 1,8-cineole and α-terpineol. Among these, terpinen-4-ol is primarily responsible for the antifungal, antibacterial and anti-inflammatory properties of the oil.

Mechanism of Action:

Tea Tree Oil exhibits broad-spectrum antifungal activity against dermatophytes, yeasts (Candida albicans) and filamentous fungi (Aspergillus niger). The primary mechanism involves disruption of fungal cell membrane integrity, leading to leakage of essential intracellular materials such as potassium ions and nucleic acids, thereby causing fungal cell death. Additionally, TTO inhibits fungal respiration and affects ergosterol biosynthesis, which is essential for maintaining fungal membrane structure.

Scientific Evidence:

Reported that Tea Tree Oil and its main constituent terpinen-4-ol demonstrated potent antifungal effects against Candida albicans and Trichophyton mentagrophytes by altering membrane permeability and disrupting cellular homeostasis. The oil also showed significant anti-inflammatory and wound-healing properties, which aid in skin recovery after infection. (6)

Fig. No. 2: Tea Tree Oil

5.3. Lemongrass oil

Source and extraction:

Lemongrass oil is extracted by steam distillation of the fresh or dried leaves and stalks of cymbopogon citratus (west indian lemongrass) or cymbopogon flexuosus (east indian lemongrass). The oil is light yellow with a pleasant lemon aroma and high volatility.

Chemical composition and active principle:

The major constituent of lgo is citral, a natural mixture of two geometric isomers — geranial (trans-citral) and neral (cis-citral) — together constituting about 65–85% of the total oil content. Other components include myrcene, geraniol and limonene. These compounds contribute to the oil's strong antimicrobial, antifungal, and antioxidant activity.

Mechanism of action:

Lemongrass oil acts by **disrupting the fungal cell membrane** and **inhibiting ergosterol biosynthesis**, a key component of fungal membranes. This leads to increased membrane permeability and cell death. The citral component also denatures fungal proteins and enzymes essential for metabolism. Studies have shown that lgo is particularly effective against candida spp. And aspergillus niger, which are common causes of superficial fungal infections.

Scientific evidence:

Majewska and góral (2019) evaluated the antifungal efficacy of lemongrass oil and reported

that the high citral content was directly responsible for its strong antifungal and antioxidant properties, making it suitable for use in topical formulations. (7)

Fig. No. 3: Lemongrass oil

6. INTRODUCTION TO LOTION FORMULATION

Definition of Lotion

A lotion is defined as a low-viscosity, biphasic liquid dosage form intended for external application to the skin. Lotions are generally emulsions, consisting of two immiscible phases — oil and water, stabilized by suitable emulsifying agents. Depending on the proportion of oil and water, lotions may be classified as oil-in-water (O/W) or water-in-oil (W/O) emulsions. They are non-occlusive, easily spreadable and rapidly absorbed, making them highly suitable for large skin surface application.(8)

Type of Formulation:

In this project, an Oil-in-Water (O/W) lotion is selected as the most appropriate formulation type for delivering Tea Tree Oil and Lemongrass Extract

Type of Formulation:

In this project, an Oil-in-Water (O/W) lotion is selected as the most appropriate formulation type for delivering Tea Tree Oil and Lemongrass Extract. This type of emulsion has water as the continuous phase and oil as the dispersed phase, which provides several distinct advantages for topical antifungal formulations:

1. **Non-Greasy Texture:**
   O/W lotions are light, non-oily, and leave no greasy residue after application, improving user acceptability and comfort.
2. **Enhanced Spreadability:**
   Due to their low viscosity, O/W emulsions spread uniformly over large skin areas, ensuring even distribution of the active ingredients.
3. **Cooling and Soothing Effect:**
   The high water content of O/W lotions provides a cooling and refreshing sensation, which helps relieve itching, burning and inflammation commonly associated with fungal infections.
4. **Improved Patient Compliance:**
   The pleasant, non-sticky nature of O/W lotions makes them more acceptable to users compared to oily creams or ointments, especially for daytime use.
5. **Compatibility with Herbal Extracts:**
   Tea Tree Oil and Lemongrass Oil, being volatile and lipophilic, can be efficiently emulsified within the oil phase, while the water phase ensures better absorption and reduced irritation.
6. **Faster Absorption:**
   The aqueous external phase allows quick absorption of the active components through the skin, providing faster therapeutic action.
7. **Stability and Aesthetic Appeal:**
   O/W emulsions can be easily stabilized with natural emulsifiers like cetostearyl alcohol, stearic acid or polysorbates, giving the lotion a smooth, elegant appearance.
8. **Suitable for Inflamed or Sensitive Skin:**
   Because of its high water content and low oil proportion, O/W lotion is gentle and non-occlusive, making it suitable for irritated or infected skin. (9)

7. FORMULATION TABLE - PER 100 G BATCH

Sr. No.	Ingredients	Function	F1 (%)	F2 (%)	F3 (%)
1	Tea Tree Oil	Active ingredient (antifungal)	1.0	1.5	2.0
2	Lemongrass Oil	Active ingredient (antifungal, deodorant)	0.5	1.0	1.5
3	Stearic Acid	Emulsifying agent / thickener	4.0	4.0	4.0
4	Cetyl Alcohol	Emollient / stabilizer	1.5	1.5	1.5
5	Liquid Paraffin	Oil base / occlusive agent	5.0	5.0	5.0
6	Glycerin	Humectant / moisturizer	3.0	3.0	3.0

7	Propylene Glycol	Penetration enhancer / co-solvent	2.0	2.0	2.0
8	Triethanolamine (TEA)	Emulsifier / neutralizer	1.0	1.0	1.0
9	Methyl Paraben	Preservative	0.18	0.18	0.18
10	Propyl Paraben	Preservative	0.02	0.02	0.02
11	Distilled Water	Vehicle / continuous phase	q.s. to 100	q.s. to 100	q.s. to 100

8. FORMULATION PROCEDURE

Method: Oil-in-Water (O/W) Emulsion Technique

The Oil-in-Water (O/W) emulsion method was selected for the preparation of the antifungal lotion because it provides a non-greasy, easily spreadable and cosmetically acceptable base, suitable for topical application. O/W emulsions allow for effective release and skin penetration of essential oils, while maintaining product stability and user comfort. (10)

1. Preparation of the Oil Phase

The oil phase consists of lipid-soluble ingredients that are melted and homogenized together. The following components were accurately weighed using an analytical balance:

- **Stearic Acid (4%)** – acts as an emulsifying and thickening agent, providing viscosity and creamy texture.
- **Cetyl Alcohol (1.5%)** – functions as an emollient and stabilizer, enhancing the smoothness of the lotion.
- **Liquid Paraffin (5%)** – serves as an occlusive base, preventing moisture loss and improving spreadability.

All ingredients of the oil phase were transferred into a clean 250 ml beaker and placed on a water bath maintained at 70–75°C. The heating ensures complete melting of stearic acid and uniform mixing of lipid components. Stirring was done continuously using a glass rod or magnetic stirrer to prevent overheating or localized burning of the fatty acids. (11)

2. Emulsification Process

Once both the oil and aqueous phases reached identical temperatures (70–75°C), the aqueous phase was added slowly to the oil phase (not vice versa) under continuous stirring using a mechanical or magnetic stirrer at 1000–1200 rpm for 15–20 minutes.

This slow addition allows for proper dispersion of water molecules into the oil phase, forming a uniform Oil-in-Water emulsion. The mixture gradually turns milky white and viscous, indicating successful emulsification. Continuous stirring is essential to achieve homogeneity and prevent phase separation. (12)

3. Cooling and Incorporation of Active Ingredients

After emulsification, the mixture was allowed to cool gradually to 40°C, as essential oils are volatile and can degrade at higher temperatures. When the temperature reached around 40°C, the active ingredients were incorporated:

- **Tea Tree Oil (Melaleuca alternifolia)** – 1.0%, 1.5%, 2.0% (varied in F1–F3)
- **Lemongrass Oil (Cymbopogon citratus)** – 0.5%, 1.0%, 1.5% (varied in F1–F3)

Both essential oils were accurately measured and added dropwise to the emulsion with continuous stirring to ensure uniform dispersion and maximum therapeutic efficacy. The essential oils possess strong antifungal, antibacterial and deodorant properties, contributing to both the medicinal and aesthetic characteristics of the lotion. (13)

4. Ph Adjustment and Neutralization

After complete mixing of the active ingredients, Triethanolamine (TEA, 1%) was added dropwise to the formulation. TEA plays a dual role as an emulsifier and ph adjuster. It neutralizes the fatty acids (stearic acid) present in the oil phase, leading to the formation of anionic emulsifiers that stabilize the O/W system.

The ph was adjusted to 6.0–7.0, which is suitable for skin application. Ph measurement was done using a digital ph meter. The gradual addition of TEA with constant stirring prevents over-neutralization and ensures uniform lotion formation. (14)

5. Final Cooling and Packaging

After ph adjustment, the mixture was allowed to cool to room temperature (25°C) under gentle stirring to prevent air entrapment and foam formation. The resulting lotion was smooth, homogenous and non-greasy. It was transferred to airtight, amber-coloured bottles to protect the formulation from oxidation, volatilization and photodegradation of the essential oils. The

prepared formulations (F1, F2, F3) were labelled properly and stored in a cool, dry place for further evaluation. (11)

6. Optimization of Formulation

Three formulations (F1–F3) were designed by varying the concentration of Tea Tree Oil and Lemongrass Oil while keeping other ingredients constant.

The optimized batch was selected based on the following evaluation parameters:

- Ph (should be near skin ph 6–7)
- Viscosity (smooth, easily spreadable)
- Homogeneity and appearance
- Spreadability (cm^2/s)
- Antifungal activity (zone of inhibition against Candida albicans and Aspergillus niger)
- Stability studies (temperature and centrifugation tests)

The optimized formulation (F2) showed ideal physical properties, acceptable ph, good spreadability and superior antifungal activity compared to other batches.

9. Evaluation Parameters (Quality Control)

9.1. Organoleptic Properties (Colour, Odor, Appearance, and Homogeneity)

Organoleptic evaluation is the simplest but one of the most important methods to assess sensory acceptability and uniformity of a topical preparation. It includes visual inspection for colour and homogeneity, as well as olfactory assessment for fragrance. These characteristics are crucial for patient compliance, as lotions with unpleasant appearance or odour are less likely to be used consistently.(12)

9.2. Ph Determination

The ph of topical formulations is critical for skin compatibility. Human skin typically has a slightly acidic ph (4.5–6.5) and deviation can cause irritation, dermatitis or microbial growth. Ph measurement ensures that the lotion is safe and non-irritant.(12)

9.3. Viscosity Measurement

Viscosity measurement evaluates the flow behavior and consistency of the lotion. It ensures the formulation is thick enough to stay on the skin, but not too viscous to hinder spreadability.(14)

9.4. Spreadability

Spreadability indicates how easily the lotion distributes over the skin, affecting patient comfort and absorption of active ingredients. It indirectly reflects viscosity and consistency.(12)

9.5. Washability & Ease of Removal

O/W lotions are designed to be water-washable while leaving the skin soft and hydrated. Testing washability ensures the formulation does not leave a greasy or sticky residue, which is a critical cosmetic property.(13)

9.6. Phase Separation

Phase separation indicates instability in emulsions and is observed as creaming, sedimentation, or oil layer formation. A stable emulsion ensures uniform drug delivery and long shelf life.(14)

9.7. Antifungal Activity

Evaluates the therapeutic efficacy of Tea Tree Oil and Lemongrass Oil in the lotion against fungal strains.(13,14)

9.8. Stability Study

Stability studies evaluate physical, chemical, and microbial stability under different storage conditions. These tests ensure shelf life and consistent performance of the lotion .(11,15)

11. SUMMERY AND CONCLUSION:

This project focused on the formulation and evaluation of an innovative Antifungal Lotion using the synergistic potential of the essential oils Tea Tree Oil (TTO) and Lemongrass Oil (LGO), aiming to provide a safer, more effective topical alternative to synthetic drugs. The rationale was built upon the distinct yet complementary mechanisms of the two oils: TTO's active component, terpinen-4-ol, disrupts the fungal cell membrane integrity, while LGO's primary component, citral, inhibits ergosterol biosynthesis, ensuring a multi-target action. The final product was formulated as a patient-friendly, non-greasy Oil-in-Water (O/W) lotion and was subjected to comprehensive evaluation, including physicochemical tests (ph, viscosity, spreadability) and the critical determination of its antifungal efficacy using the Agar Well Diffusion Method against common fungal strains.

The project successfully achieved its objectives by identifying the optimal formula, Formulation F2, which exhibited the best balance of physicochemical properties, characterized by a skin-compatible ph and desirable spreadability, confirming its suitability for topical use. Critically, the evaluation results demonstrated that this optimized TTO-LGO formulation possessed significant, confirmed antifungal activity, proving its potential as a highly effective herbal treatment. The stability studies further validated the formulation's physical and chemical integrity over time, confirming its viability and making it a

promising candidate for further development, including advanced clinical trials and eventual commercialization as a stable, natural therapeutic option for superficial mycoses.

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