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Research Paper

Herbal Antifungal Gel Formulation: A Tea Tree Oil-Based Approach for Topical Fungal Infections

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ABSTRACT

Fungal infections, including dermatophytoses and candidiasis, have become more prevalent due to environmental changes and weakened immune systems. Herbal treatments are gaining attention as safe and effective alternatives to conventional therapies. This study focuses on creating a herbal antifungal gel containing tea tree oil, renowned for its antifungal, antimicrobial, and anti-inflammatory properties. The gel formulation also includes stabilizers and preservatives such as Carbopol, propylene glycol, triethanolamine, and di-sodium EDTA to enhance stability, spreadability, and preservation. Thin-layer chromatography (TLC) was employed to identify any residue of tea tree oil. Various physicochemical tests, including pH, spreadability, viscosity, and stability, were conducted to assess the gel's quality and user-friendliness. Chemical compatibility tests ensured the formulation's integrity. The results demonstrated that the herbal antifungal gel exhibited notable antifungal activity, favourable physicochemical properties, and good compatibility with the skin, indicating its potential as an effective natural alternative for treating fungal skin infections. Further studies are recommended to evaluate its clinical efficacy and long-term stability.

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INTRODUCTION

Gels are semi-solid systems where the consistency of the dispersing medium is controlled by the interactions between particles or the ability of large molecules to dissolve in the dispersed phase [1], [2]. Gels are a highly diluted, cross-linked system that does not flow in a steady state. They consist of a two-component, semi-solid system with a high liquid content. One key characteristic of gels is their continuous structure, which gives them solid-like properties. Gels are increasingly preferred for drug delivery formulations because of their biocompatibility, network structure, and the molecular stability of the bioactive ingredients they contain. The main goal of delivering medications through the skin is to enhance systemic absorption or provide localized treatment. While intravenous administration bypasses gastrointestinal side effects, it is invasive. In contrast, topical preparations that act as a barrier improve patient compliance and can often be self-administered. [3], [4],[5] Tea tree oil (TTO) is an essential oil and is commonly used as a topical antiseptic. It exhibits a broad spectrum of antifungal activity against various bacteria, viruses, fungi, yeasts, and dermatophytes. The key component responsible for its confirmed antifungal properties is terpinen-4-ol. [4] In the development of a herbal antifungal gel, several excipients are crucial for ensuring its effectiveness, stability, and compatibility with the skin. Carbopol functions as a gelling agent, providing the necessary viscosity and enabling the controlled release of the active components. Sodium di-EDTA enhances the formulation's stability by chelating metal ions, preventing oxidation, and prolonging shelf life. Tea tree oil, known for its antifungal properties, effectively combats fungal infections while also providing anti-inflammatory effects. Propylene glycol acts as a humectant and solvent, aiding in skin hydration and enhancing the absorption of active ingredients. Methyl paraben serves as a preservative, safeguarding the gel from microbial contamination, while triethanolamine neutralizes Carbopol, adjusting the pH to ensure skin compatibility. Together, these excipients create a stable, effective, and skin-friendly herbal antifungal gel.

MATERIAL AND METHOD:

MATERIAL:

Tea Tree Oil Contains terpinen-4-ol, which Acts as the primary antifungal agent due to its broad-spectrum activity. Carbopol 940 is Synthetic polymer Provides the gel structure and enhances viscosity. Triethanolamine Neutralizes Carbopol and adjusts the gel's pH to match skin's natural pH (~5.5-6.5). Propylene Glycol Enhances penetration of tea tree oil into the skin. Di-sodium EDTA. Binds metal ions to prevent oxidation and degradation of the active ingredient. Methyl Paraben Prevents microbial contamination and extends shelf life.

Preparation of Gel:

Beker 1 - The Carbopol 940 was dissolved slowly with stirring in q.s of distilled water for 1 hour. Beker 2 – take di-sodium EDTA and triethanolamine were dissolved in distilled water and stirred for 10 minutes. Beker 3 – take propylene glycol was mixed with tea tree oil also add methyl Paraben as preservative. Beaker-2 solution was added to Beaker-1 solution and the PH was adjust to 6.5 by stirring the solution for 10 min. The beaker-C solution was added in prepare solution by stirring for 10 min until clear consistent base gel was obtained. [5]

Table 1. Formulation Composition

Sr. No	Ingredients	Purpose	Formula 1 (F1)	Formula 2 (F2)	Formula 3 (F3)
1.	Tea Tree oil	Antifungal agent	1.5ml	1.5ml	2.5ml
2.	Carbopol	Gelling agent	2gm	1.5gm	1gm
3.	Triethanolamine	PH adjuster, Neutralizer	1.6ml	1.6ml	1.5ml
4.	Propylene glycol	Humectant, Penetration enhancer	1ml	1.5ml	1.5ml
5.	Di-Sodium EDTA	Chelating agent, Stabilizing agent	2gm	2.5gm	2gm
6.	Methyl Paraben	Preservative	1gm	0.5gm	0.2gm
7.	Purified Water	--	q.s	q.s	q.s

Evaluation Parameters:

Physical Appearance:

The prepared gel was visually inspected for color, homogeneity, and clarity. The formulation was white in color, smooth in texture which indicating good physical stability. [6],[7],[8]

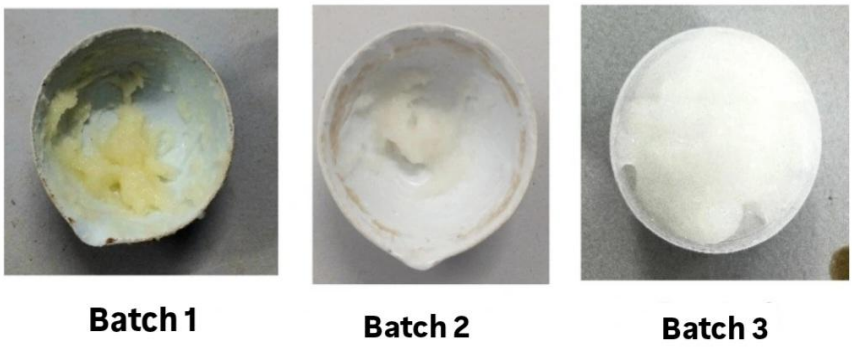

Figure 1. of gel batches

pH Determination:

The pH of the prepared gel formulations was measured using a digital pH meter. 1 gram of gel was dissolved in 100 ml of distilled water and left for 2 hours. The pH was then measured, and the average value was calculated [7],[16] Compare to the standard value the observed pH value fell within the 5 - 6.5 range.

Spreadability Test:

Two glass slides of standard dimensions were prepared. The herbal gel formulation was applied to one slide, and the other slide was placed on top, sandwiching the gel between them over a 7.5 cm length. A 100 g weight was placed on the upper slide to apply uniform pressure, forming a thin layer of gel. After removing the weight, any excess gel adhering to the slides was scraped off. Spreadability was determined using the formula:

$$S = m \times l / t$$ [8],[9],[10]

The Spreadability test indicates that F3 exhibits the best spreadability, ensuring the smooth application.

Rheological Study:

The viscosity of the prepared gel formulations was measured by using a Brookfield viscometer. [11] It indicates that the formulation maintained an optimal viscosity, ensuring easy application and uniform spreading.

Clarity:

The clarity of the gel showed that it was free from visible particles and no phase separation. [12]

Chromatographic Analysis:

Thin Layer Chromatography was conducted for the terpinene-4-ol by using Toluene: Ethyl Acetate in 9.5:0.5 ratio. Sample is prepared by diluting tea tree oil in Hexane. The Rf value of terpinene-4-ol was found to be 0.60 which is in the range of the standard range which is 0.46 - 0.62. [13]

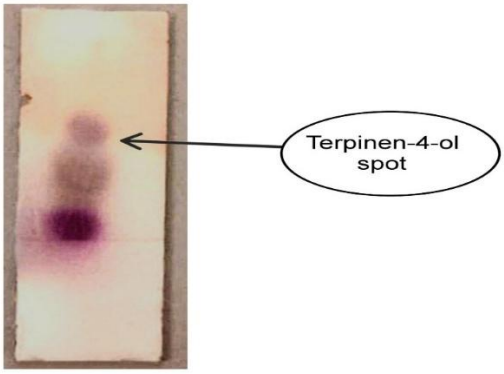

Figure 2. of TLC Plate

Antimicrobial Test:

By performing antimicrobial assay, it can be ensured that prepared gel is safe for topical use. The prepared bacterial suspension was applied to agar media plates using the streak plate technique, alongside a control plate. These plates were then incubated at 37C for a 24-hrs. Following incubation, the plates were removed and examined the zone of inhibition of each prepared batch.[14] The gel formulation exhibited the highest zone of inhibition indicating its superior antifungal activity.

RESULT:

Table 2. of result

Sr.No	Characteristics	Observation (F1)	Observation (F2)	Observation (F3)
1	Colour	Pale Yellow	White	White
2	Odour	Characteristic	Characteristic	Characteristic
3	pH	5.8	6.0	6.3
4	Spreadability	Poor	Moderate	Good
5	Clarity	Clear	Clear	Clear
6	Phase Separation	No	No	No
7	Anti-microbial Test	12.5 mm	14.2 mm	18.7 mm

CONCLUSION:

The development of an herbal antifungal gel incorporating tea tree oil has shown promising results as an effective alternative treatment for topical fungal infections. The formulation demonstrated strong antifungal activity, with tea tree oil's key compound, terpinen-4-ol, exhibiting efficacy against various dermatophytes and fungi.

The gel's physical properties, including pH, spreadability, viscosity, and clarity, were within acceptable limits, indicating its potential for smooth application and patient compliance. Among the three formulation variants tested, F3 exhibited the best spreadability, providing an optimal texture for user application. The absence of phase separation and the clear, stable consistency of the gel further enhance its appeal as a reliable, shelf-stable product. The TLC analysis confirmed the presence of active components in the gel, affirming the integrity and concentration of tea tree oil. The inclusion of excipients such as Carbopol, propylene glycol, and methyl paraben enhanced the formulation's stability, skin compatibility, and preservation. Based on the observed physicochemical properties and antifungal activity, the herbal antifungal gel has great potential as a natural, non-invasive treatment for skin infections. Future studies are recommended to explore its clinical efficacy, long-term stability, and broader application in the field of dermatology.

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