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Review

Development and Evaluation of a Topical Herbal Gel Incorporating *Peltophorum pterocarpum* Ethanolic Extract: An Antifungal Approach Against Candidiasis

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Abstract:

Background: *Peltophorum pterocarpum* is a medicinal plant rich in flavonoids, tannins, phenolics, and saponins, which possess promising antimicrobial and antifungal properties. Developing herbal topical gels from its pod extract may provide a safe and effective alternative for the management of superficial fungal infections. **Methods:** The pod extract was prepared by Soxhlet extraction using ethanol and incorporated into Carbopol 940 gel. Four formulations (F1–F4) containing different concentrations of Carbopol and plant extract were prepared. The formulations were evaluated for physical appearance, pH, viscosity, spreadability, homogeneity, consistency, and washability. **Results**: All formulations exhibited satisfactory physical characteristics with no phase separation and good homogeneity. The pH values were within the acceptable range for topical application. Increasing Carbopol concentration increased viscosity while reducing spreadability. Among the formulations, F2 showed the best balance of pH, viscosity, spreadability, consistency, and washability, making it the optimized formulation.

Keywords: *Peltophorum pterocarpum*; herbal gel; Carbopol 940; topical formulation; physicochemical evaluation; pod extract.

INTRODUCTION

A gel is a semisolid dosage form consisting of a three-dimensional network of polymer chains or colloidal particles that entraps a liquid phase within its matrix. In pharmaceutical formulations, a gelling agent (gelator) is incorporated with the active ingredient and solvent to produce the desired gel structure. Gelators may be either low-molecular-weight compounds or polymeric materials, while the dispersion medium may be aqueous, organic, inorganic, or a combination of solvents. Topical gels are intended for application to the skin, where they act as vehicles for the localized or transdermal delivery of therapeutic agents. The three-dimensional gel network entraps drug molecules and facilitates their controlled release. Gels exhibit unique characteristics such as firmness, rheological behavior, swelling, aging, and syneresis, and they can be classified based on their physical nature, colloidal system, or the type of solvent used [1].

Among the various topical dosage forms, such as creams, ointments, and lotions, gels are considered one of the most effective drug delivery systems for topical therapy. They are non-greasy, easily spreadable, washable, and provide a cooling sensation upon application. In addition, gels exhibit better patient acceptability, enhanced drug release, improved penetration into the affected area, and minimal residue on the skin. These advantages make topical gels

particularly suitable for the localized treatment of superficial fungal infections and for the incorporation of herbal extracts with improved therapeutic efficacy [2].

Candidiasis is the most commonly encountered opportunistic mycosis fungal infection worldwide. *Candida albicans* is the most common species in the genus which has been implicated in Candidiasis. The infections range from superficial skin to systemic diseases. *C.albicans, C. tropicalis, C. glabrata,* and *C. parapsilosis* are part of the normal flora of humans and can be isolated from oral cavities, vaginal and other parts of body sites from normal healthy people. Under certain circumstances, these organisms may gain access to many organ systems such as lungs, spleen, kidneys, liver, heart, brain, eye, skin, and others. Lesions may occur in patients who have disseminated infections. Current Treatment available for Candidiasis are as: Topical antifungal: Ketoconazole, Miconazole, Nystatin, for Systemic: Amphotericin B, Fluconazole, and Itraconazole and for Chronic mucocutaneous: Amphotericin B, Fluconazole, Itraconazole but with these synthetics drugs there are certain side-effects [3].

Peltophorum pterocarpum is a medicinal tree belonging to the family Caesalpiniaceae (Fabaceae). It is widely distributed in Sri Lanka, India, Malaysia, northern Australia, and Southeast Asia and is commonly known as the copper pod or yellow flame tree. Traditionally, different parts of the plant, including the bark, leaves, and pods, have been used in folk medicine for the treatment of wounds, skin disorders, and oral diseases. Phytochemical investigations have demonstrated the presence of flavonoids, tannins, phenolic compounds, saponins, and other bioactive constituents that contribute to its antimicrobial, antioxidant, and antifungal activities. These pharmacological properties suggest that *P. pterocarpum* is a promising natural source for the development of herbal antifungal formulations [4].

MATERIAL AND METHODOLOGY

PLANT MATERIAL

The *Peltophorum pterocarpum* pod material used in this study was collected from the ACP Medicinal Garden, Tiruvannamalai.

METHODOLOGY

PREPARATION OF PLANT EXTRACT

Peltophorum pterocarpum pod was shade-dried and coarsely powdered. About 180 g of the powdered material was subjected to Soxhlet extraction using ethanol as the extraction solvent. The extraction was continued until the solvent in the siphon tube became nearly colorless, indicating exhaustive extraction. The extract obtained was concentrated by evaporating the solvent on a hot plate. The dried extract was weighed and stored in a refrigerator until further use.

PREPARATION OF HERBAL GEL BASE

Carbopol 940 was used as the gelling polymer for the preparation of the topical gel. Four gel formulations (F1–F4) were prepared by varying the concentration of Carbopol 940 at 0.5%, 1.0%, 1.5%, and 2.0% (w/w), respectively. The required quantity of Carbopol 940 was dispersed in a sufficient quantity of distilled water (q.s.) using a magnetic stirrer with continuous stirring until a uniform dispersion was obtained. The dispersion was allowed to hydrate for 24 hours to ensure complete swelling of the polymer. Triethanolamine (0.5 mL) was then added gradually with continuous stirring to neutralize the Carbopol dispersion and obtain the desired gel consistency. The pH of the gel was adjusted to approximately 5.5–6.5 to ensure compatibility with the skin. The prepared gel base was used for the mixing of the plant extract.[5]

The ethanolic extract of *Peltophorum pterocarpum* was proved to have an antifungal activity against candida tropicalis in our previous *in vitro* study [6].

FORMUALATION OF HERBAL GEL

Four herbal gel formulations (F1–F4) were prepared by incorporating different concentrations of the *Peltophorum pterocarpum* ethanolic extract (0.4 g, 0.6 g, 0.8 g, and 1.0 g, respectively) into the prepared Carbopol 940 gel base. Methyl paraben (0.1 g) and propyl paraben (0.025 g) were dissolved slowly in propylene glycol (2.5 mL) with continuous stirring. The required quantity of the herbal extract was then incorporated into this mixture and mixed thoroughly. Finally, the extract mixture was added gradually to the prepared Carbopol 940 gel base with continuous homogenization until a smooth, homogeneous gel with the desired consistency was obtained [5].

EVALUATION TESTS

1.Physical appearance

The physical appearance of the formulation was checked visually.

- **Color**: The color of the formulations was checked out against white & black backgrounds.
- **Consistency**: The consistency was checked by applying gel on the skin.
- **Greasiness**: The greasiness was assessed by the application on the skin.
- **Phase separation**: The formulation was visually examined for any signs of phase separation after preparation and storage at room temperature. No phase separation was observed, indicating good physical stability of the gel.
- **Odor**: The odor of the gels was checked by mixing a little amount of gel in water and by taking smell [7].

2.Spreadability

The spreadability of gel formulations was determined by measuring the spreading diameter of 1 g of gel between two horizontal plates (20 × 20 cm) as reported by Meera et al. (2010) with slight modifications. The horizontal plates weighed 125 g each, 1 g of the formulated gel was weighed and kept carefully on the horizontal glass slide. The second glass slide was placed on top of the gel and the time taken for the gel to spread in 1 min was recorded. A measuring rule was used to measure the diameter of the gel, and the readings were taken from the three sides of the circle. The mean of the diameters was recorded. This test was repeated for all the formulations in triplicates [8].

3. Viscosity

The viscosity of the prepared herbal gel was measured using a Digital Rotational Viscometer (LABMAN LMDV-60) at 25 ± 2°C using Spindle No. 4 (SP4) at a spindle speed of 12 rpm. The viscosity was recorded in centipoise (cP) [5].

4. pH determination

The produced gel formulation pH is measured using a digital pH meter. After dissolving 1 g of gel in 100 ml of distilled water, it was kept for 2 hours. To prevent any kind of skin irritation, the pH of the topical gel formulations was determined in the range of 5.5-6.5 which is close to the natural pH of the skin.

5. Homogeneity

A small quantity of gel was spread on a clean glass slide and visually examined for uniformity, lumps, air bubbles, and phase separation. The observations were recorded. [9].

6.Washability

The prepared herbal gels are much easier to wash away from the skin surface. The washability test was determined by applying a small amount of prepared formulation on the skin surface and then washing it with water. The formulations showed good washability [5].

RESULTS AND DISCUSSION

FORMULATION COMPOSITION (50gm)

The formulation composition of the herbal gel (50 g) is presented in Table 1. Four formulations (F1–F4) were prepared by varying the concentrations of the pod extract and Carbopol 940, while the remaining excipients were kept constant

Table:1 Formulation of herbal gel composition

S.No	Ingredients	Purpose	Formula (F1)0.5%	Formula (F2)1%	Formula (F3)1.5%	Formula (F4) 2%
1.	Pod extract	Antifungal agent	0.4gm	0.6gm	0.8gm	1gm
2.	Carbopol 940	Gelling agent	0.25gm	0.50gm	0.75gm	1gm
3.	Propylene glycol	Penetration enhancer	2.5ml	2.5ml	2.5ml	2.5ml
4.	Methyl paraben	Preservative	0.1gm	0.1gm	0.1gm	0.1gm
5.	Propyl paraben	Preservative	0.5ml	0.5ml	0.5ml	0.5ml
6.	Triethanolamine	pH adjuster Neutralizer	0.5ml	0.5ml	0.5ml	0.5ml
7.	Glycerin	Humectant	1ml	1ml	1ml	1ml
8.	Distilled water	Vehicle	q.s	q.s	q.s	q.s

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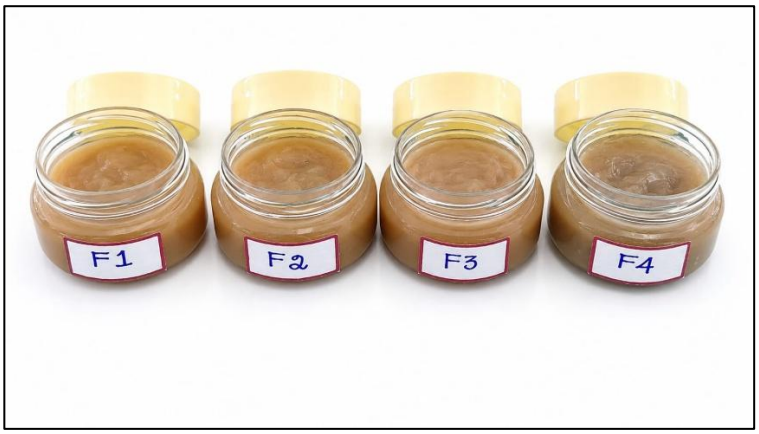

Figure 1: Herbal Gel

Among the four formulations, the concentrations of the pod extract and Carbopol 940 were varied to optimize the gel characteristics. All formulations contained the same amounts of propylene glycol, glycerin, preservatives, triethanolamine, and distilled water (q.s.) to obtain a uniform gel base.

EVALUATION OF HERBAL GEL

The prepared herbal gel formulations were subjected to physicochemical evaluation using standard procedures. The evaluation parameters and their corresponding results are presented in Table 2

Table:2 Physicochemical Evaluation of the Prepared Herbal Gel Formulation

S. No.	Evaluation parameters		F1(0.5%)	F2 (1%)	F3(1.5%)	F4(2%)
1	Physical appearance	Color	Light brown	Yellowish brown	Yellowish brown	Dark brown
		Odor	Characteristic	Characteristic	Characteristic	Characteristic
		greasiness	Non-greasy	Non-greasy	Non-greasy	Non-greasy
		Phase separation	No separation	No separation	No separation	No separation
		Consistency	Poor	Excellent	Good	Moderate
2	**pH** (5.5-6.5)		6.7	5.9	6.8	5.9
3	**Viscosity (**mPa·s**) (20,000 -40,000 cp)**		6965.5	27,805	37,889	84,489
4	**Spreadability (cm) (5-7cm)**		6.16	5.93	4.90	3.60
5	**Homogeneity**		Homogenous	Homogenous	Homogenous	Homogenous
6	**Washability**		Good	Good	Good	Good

Table 2 shows the physicochemical evaluation of the prepared herbal gel formulations (F1–F4). The color of the formulations changed from light brown to dark brown with increasing concentration of the pod extract. All formulations exhibited a characteristic odor, homogeneous appearance, no phase separation, and good washability, indicating good physical stability. The pH values ranged from 5.9 to 6.8, which are suitable for topical applications. As the concentration of Carbopol 940 increased, the viscosity increased, while the spreadability decreased. F1 showed poor consistency, a viscosity of 6965.5 mPa·s, and the highest spreadability (6.16 cm), indicating a thin gel. F2 exhibited excellent consistency, a pH of 5.9, an optimum viscosity of 27,805 mPa·s, and good spreadability (5.93 cm), making it the most balanced

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formulation. F3 showed good consistency, a viscosity of 37,889 mPa·s, and a spreadability of 4.90 cm. F4 exhibited moderate consistency, the highest viscosity (84,489 mPa·s), and the lowest spreadability (3.60 cm), indicating a thick gel. Based on the overall physicochemical evaluation, F2 was selected as the optimized herbal gel formulation because it showed the best balance of pH, viscosity, spreadability, consistency, homogeneity, and washability, making it suitable for topical application.

The following figures will show the results of evaluating herbal gel through the parameters like pH, Viscosity, Homogeneity, spreadability and Washability.

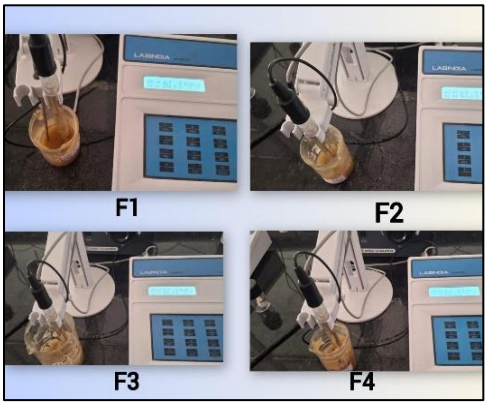


Figure 2: pH

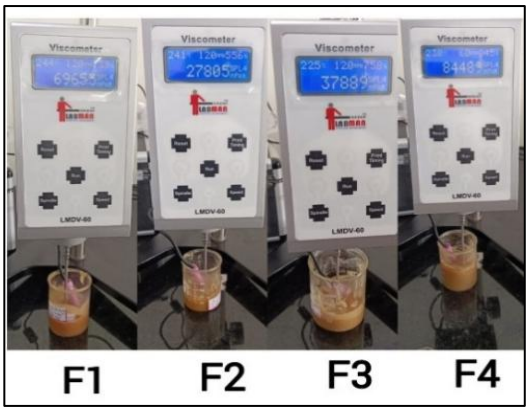


Figure 3: Viscosity

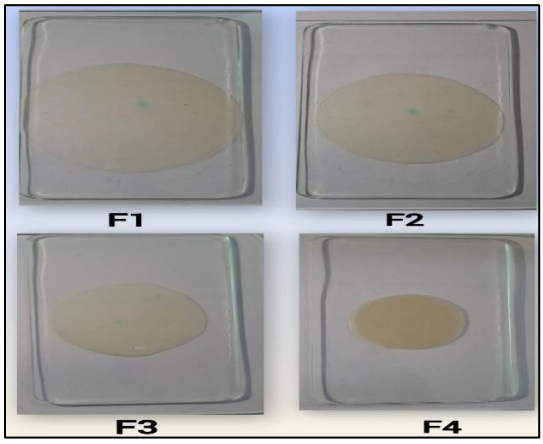


Figure 4: Spreadability

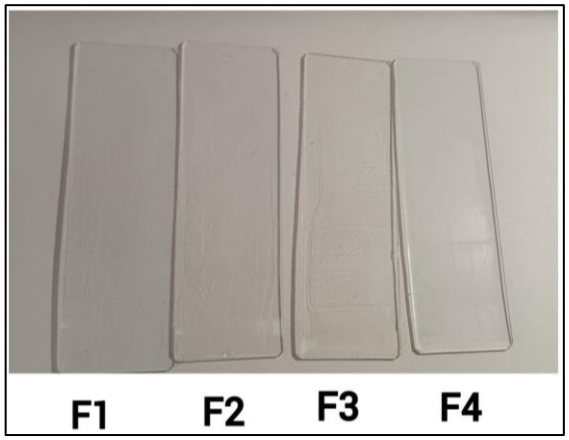
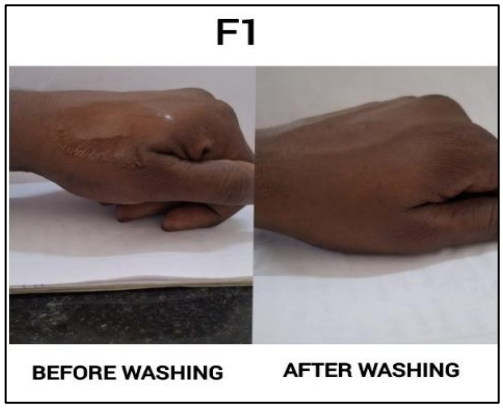


Figure 5: Homogeneity



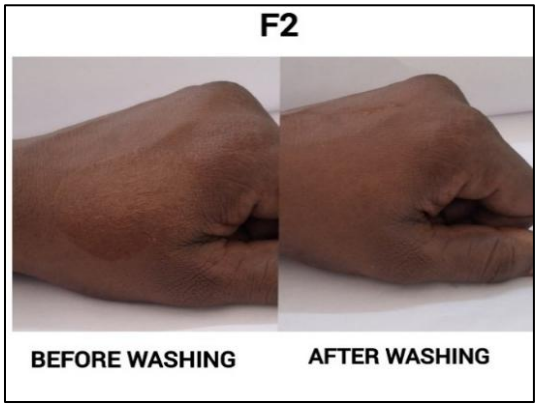


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Figure 6: Washability

DISCUSSION

The study by Prathyusha K et al., (2025) reported the successful formulation of a *Peltophorum pterocarpum* leaf extract gel with acceptable physicochemical properties, including skin-compatible pH, good viscosity, homogeneity, and spreadability. However, the formulation exhibited only mild antibacterial activity against *Escherichia coli* and *Bacillus subtilis*, which the authors attributed to the low extract concentration and suggested that further optimization could improve its therapeutic efficacy [10].

The study by Mamillapalli et al. (2018), who formulated a Carbopol 940-based herbal gel containing the ethanolic leaf extract of *Peltophorum pterocarpum.* The optimized formulation exhibited good physicochemical properties, including a pH of 6.82, viscosity of 8.54, good consistency, smooth appearance, easy washability, and a spreadability time of 4.3 s, indicating the suitability of *Peltophorum pterocarpum*-based gels for topical application [11].

In the present study, ethanolic pod extract of *Peltophorum pterocarpum* was incorporated into Carbopol 940 gel and evaluated by preparing four formulations (F1–F4). Similar to the reference study, all formulations showed satisfactory physical appearance, homogeneity, and skin-compatible pH. An increase in Carbopol concentration resulted in increased viscosity and decreased spreadability. Among the formulations, F2 exhibited the best balance of pH, viscosity, spreadability, consistency, and washability, making it the optimized formulation for topical application.

Unlike the reference study, which focused on antibacterial evaluation of a single leaf-based formulation, the present work emphasized the optimization of a pod-based herbal gel by comparing multiple formulations. The optimized formulation demonstrated desirable physicochemical properties, indicating its potential as a stable topical antifungal gel. Further studies on antifungal activity, stability, and *in vivo* evaluation are required to confirm its therapeutic effectiveness.

CONCLUSION

The present study successfully developed and evaluated topical herbal gel formulations containing the ethanolic extract of *Peltophorum pterocarpum* pods using Carbopol 940 as the gelling agent. Four formulations (F1–F4) were prepared and evaluated for their physicochemical properties. All formulations exhibited acceptable appearance, homogeneity, washability, and skin-compatible pH. Among them, formulation F2 demonstrated the most desirable characteristics, including optimum pH, viscosity, spreadability, consistency, and overall stability, making it the optimized formulation for topical application. These findings suggest that *Peltophorum pterocarpum* pod extract can be successfully incorporated into a stable herbal gel and has potential as a topical antifungal formulation. However, further studies, including antifungal activity, stability testing, skin irritation studies, and *in vivo* evaluation, are required to confirm its therapeutic efficacy and clinical applicability.

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