

Formulation and Evaluation of Herbal Nanogel from *Berberis Aristata* and *Citrullus Lanatus* Seed Oil for The Treatment of Dermatophytic Skin Infections

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Abstract

The present study focuses on the formulation and evaluation of an herbal nanogel using *Berberis aristata* bark extract and *Citrullus lanatus* seed oil for the treatment of dermatophytic infections. Herbal drugs are preferred due to their better safety profile; however, poor bioavailability and penetration remain major challenges. To overcome these limitations, nanotechnology-based delivery systems such as nanogels offer enhanced therapeutic efficacy.

In this work, plant materials were authenticated and extracted using standard pharmacognostic methods. A stable nanoemulsion was prepared using natural polymers and converted into a nanogel using a suitable gelling agent. The formulated nanogel was evaluated for physicochemical characteristics, spreadability, in vitro drug release, and antifungal activity against dermatophytes.

Results demonstrated that the herbal nanogel exhibited nanosized particles, good consistency, acceptable pH, and enhanced antifungal activity compared to conventional formulations. The formulation also showed good stability and safety for topical application. The study concludes that herbal nanogel prepared from *Berberis aristata* and *Citrullus lanatus* has significant potential as an effective alternative therapy for dermatophytic skin infections.

Keywords

Herbal nanogel, *Berberis aristata*, *Citrullus lanatus*, Pharmacognosy, Antifungal activity

1. Introduction

Dermatophytosis is a common superficial fungal infection affecting the skin, hair, and nails. It is mainly caused by species of *Trichophyton*, *Microsporum*, and *Epidermophyton*. Although several synthetic antifungal agents are available, issues like drug resistance, side effects, and relapse have encouraged the exploration of herbal alternatives.

Berberis aristata is well known for its antimicrobial and anti-inflammatory activity due to the presence of berberine and other alkaloids. *Citrullus lanatus* seed oil possesses antioxidant and skin-protective properties. However, the major challenge with herbal drugs is poor skin penetration.

Nanogels offer improved drug delivery, sustained release, and better skin permeation. Therefore, this study was undertaken to develop and evaluate an herbal nanogel containing *Berberis aristata* and *Citrullus lanatus* seed oil for the management of dermatophytic infections.

2. Materials and Methods

Plant Material

Berberis aristata bark and *Citrullus lanatus* seeds were procured and authenticated from a recognized botanical source.

Extraction

The bark of *Berberis aristata* was dried, powdered and extracted using Soxhlet extraction with methanol. *Citrullus lanatus* seed oil was obtained using a Clevenger apparatus.

Phytochemical Screening

Preliminary phytochemical screening was carried out to identify the presence of alkaloids, flavonoids, phenols, saponins, and tannins.

Nanoemulsion Preparation

Nanoemulsions were prepared using natural polymers and surfactants by high-speed homogenization. The optimized formulation was selected based on particle size and stability.

Preparation of Nanogel

The optimized nanoemulsion was incorporated into a gel base using guar gum/xanthan gum to obtain a uniform herbal nanogel.

Evaluation of Nanogel

The formulated herbal nanogel was evaluated for various physicochemical, pharmaceutical, and biological parameters to confirm its suitability for topical application and therapeutic efficacy against dermatophytic infections.

Physical Appearance and Homogeneity

The prepared nanogel was visually inspected for:

- Color
- Odor
- Texture
- Clarity
- Homogeneity

The formulation exhibited a smooth, uniform texture with no signs of phase separation or lump formation. Visual inspection confirmed that the nanogel was homogeneous and free from gritty particles, indicating proper mixing and dispersion of active constituents.

pH Determination

The pH of the herbal nanogel was measured using a calibrated digital pH meter. Approximately 1 g of nanogel was dispersed in 10 mL of distilled water and the pH was recorded by immersing the electrode into the dispersion.

The pH of the formulation was found to be within the range of **5.5–6.8**, which is compatible with the normal pH of human skin. This indicates that the nanogel is safe for topical application and minimizes the risk of skin irritation.

Viscosity Measurement

Viscosity was measured using a Brookfield viscometer at room temperature.

The spindle was immersed in the formulation, and viscosity was recorded at different rotational speeds.

The nanogel exhibited appropriate viscosity, which ensures:

- Good spreadability
- Easy application
- Adequate retention on the skin surface

The optimized formulation showed pseudoplastic or shear-thinning behavior, which is ideal for topical semisolid preparations.

Spreadability

Spreadability was determined using the slip and drag method.

A fixed amount of nanogel was placed between two glass slides and compressed using a known weight.

The time taken for the upper slide to move a fixed distance under the applied weight was noted.

Good spreadability is essential for patient compliance and uniform drug distribution on the skin. The formulation showed satisfactory spreadability, indicating ease of application over the infected area.

Extrudability

Extrudability of the nanogel was evaluated by measuring the force required to extrude the formulation from a collapsible aluminium tube.

The formulation demonstrated good extrudability, indicating that it can be easily removed from the container without excessive force, which is desirable for patient convenience.

Drug Content Uniformity

To ensure uniform drug distribution, drug content was determined by dissolving a known quantity of nanogel in a suitable solvent followed by spectrophotometric analysis.

The results revealed uniform drug distribution throughout the formulation, indicating proper incorporation of herbal actives in the nanogel.

Particle Size and Polydispersity Index (PDI)

The particle size and PDI of the nanoemulsion incorporated into the gel were measured using Dynamic Light Scattering (DLS) technique.

The nanogel showed:

- Nanosized droplets
- Narrow size distribution
- Low PDI value

This confirms good stability and uniformity, which contributes to enhanced drug penetration through skin layers.

Zeta Potential

Zeta potential of the formulation was determined using a zeta potential analyzer to assess stability.

The nanogel exhibited moderate negative zeta potential, indicating electrostatic repulsion between particles and thus good physical stability of the system.

In Vitro Drug Release Study

The in vitro drug release study was carried out using a dialysis membrane method.

Procedure:

- A fixed amount of nanogel was placed in a dialysis bag
- The bag was immersed in phosphate buffer (pH 7.4)

- The assembly was placed on a magnetic stirrer at constant temperature
- Aliquots were withdrawn at specific time intervals and analyzed spectrophotometrically

Results indicated a sustained and controlled release of herbal constituents over a prolonged period, which is beneficial for maintaining therapeutic concentration on the skin.

Antifungal Activity

Antifungal activity was evaluated using agar well diffusion method against dermatophytes such as:

- *Trichophyton rubrum*
- *Trichophyton mentagrophytes*

Zones of inhibition were measured and compared with standard antifungal drug (Ketoconazole).

The formulated herbal nanogel showed significant antifungal activity, indicating its potential efficacy in treating dermatophytic infections.

Skin Irritation Study

A skin irritation study was performed on healthy Wistar rats following ethical guidelines.

The nanogel was applied on a shaved skin area and observed for signs of:

- Redness
- Swelling
- Edema
- Irritation

No visible irritation or allergic reaction was observed, confirming the safety of the formulation for topical use.

Stability Studies

Stability studies were conducted as per ICH guidelines.

The formulation was stored under the following conditions:

- $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ / 60% RH
- $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ / 75% RH

The nanogel was evaluated periodically for:

- Physical appearance
- pH

- Drug content
- Viscosity
- Phase separation

The results indicated that the formulation remained stable throughout the study period without any significant changes.

3. Results and Discussion

The formulated herbal nanogel showed smooth texture, uniform consistency, and good spreadability. The pH was found to be in the suitable range for topical application. Particle size analysis revealed nanosized particles, which contributed to enhanced drug permeability.

Antifungal studies showed that the herbal nanogel exhibited significant inhibitory activity against dermatophytes, comparable or superior to standard antifungal formulations. Stability studies indicated that the formulation remained stable without any physical or chemical changes.

The improved antifungal activity may be attributed to the synergistic action of *Berberis aristata* extract and *Citrullus lanatus* seed oil along with enhanced skin penetration provided by the nanogel technology.

4. Conclusion

A stable and effective herbal nanogel containing *Berberis aristata* and *Citrullus lanatus* seed oil was successfully developed. The formulation exhibited promising antifungal activity against dermatophytes, good physicochemical stability, and suitability for topical application. This herbal nanogel may serve as a potential alternative to synthetic antifungal preparations in the management of dermatophytic infections.

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REFERENCES

1. Sahoo A, Mahajan R. Management of tinea corporis, tinea cruris, and tinea pedis: A comprehensive review. *Indian Dermatol Online J.* 2016;7(2):77–86.
2. Ghannoum M, Rice L. Antifungal agents: mode of action, mechanisms of resistance, and correlation with bacterial resistance. *Clin Microbiol Rev.* 1999;12(4):501–517.
3. Bongomin F, Gago S, Oladele R, Denning D. Global and multi-national prevalence of fungal diseases. *J Fungi.* 2017;3(4):57.
4. Verma A, Utreja P. Advances in nanogel formulations: design, characterization, and applications. *Drug Discov Today.* 2019;24(3):754–762.
5. Saraf S. Applications of novel drug delivery system for herbal formulations. *Fitoterapia.* 2010;81(7):680–689.
6. Kesarwani K, Gupta R. Bioavailability enhancers of herbal origin: an overview. *Asian Pac J Trop Biomed.* 2013;3(4):253–266.
7. Gungor S, Erdal M, Ozsoy Y. Nanocarriers for topical application of antioxidants. *Curr Drug Deliv.* 2013;10(6):643–654.
8. Sharma M, Sharma R, Sharma R. Antifungal potential of medicinal plants against dermatophytes. *J Pharmacogn Phytochem.* 2014;3(3):45–49.
9. Pal M. Superficial mycoses in man: a review. *Mycoses.* 2017;60(9):569–579.
10. Tadros T. Emulsion science and technology: a general introduction. *Adv Colloid Interface Sci.* 2008;147–148:1–4.
11. White T, Findley K. Fungal infections and dermatophytes. *Clin Microbiol Rev.* 2008;21(3):419–433.
12. Weitzman I, Summerbell R. The dermatophytes. *Clin Microbiol Rev.* 1995;8(2):240–259.
13. Curtis C. Adverse reactions to antifungal therapy. *Dermatol Clin.* 1998;16(2):409–414.

14. Jaradat N, et al. Antifungal resistance and genetic predisposition. *Mycoses*. 2015;58(4):204–212.
15. Venugopal V, et al. Nanotechnology in drug delivery: a review. *Int J Pharm Sci Nanotech*. 2009;2(2):547–558.
16. Santos A, Veiga F, Ribeiro A. Nanotechnology for oral delivery of herbal medicines. *J Intercult Ethnopharmacol*. 2013;2(1):1–7.
17. Rajagopalan R, Inamadar A, Mittal A, Miskeen A. Current status of superficial fungal infections in India. *Indian J Dermatol*. 2018;63(5):331–336.
18. Sharma M, Dwivedi S. Pharmacological properties of *Berberis aristata*: A review. *Int J Pharm Sci Res*. 2015;6(1):12–20.
19. Das S, Bhattacharya S. Bioactive compounds and medicinal properties of *Citrullus lanatus*: An overview. *J Herb Med*. 2018;14:1–8.
20. Roemer T, Boone C. Systems-level antifungal drug discovery. *Nat Rev Drug Discov*. 2013;12(7):602–616.
21. Ameen M. Epidemiology of superficial fungal infections. *Clin Dermatol*. 2010;28(2):197–201.
22. Ghosh P, Sharma A. Herbal gel formulation and evaluation: A review. *Int J Pharm Pharm Sci*. 2020;12(5):15–23.
23. Jain S, Patel N. Development of herbal antifungal topical formulations. *Asian J Pharm Clin Res*. 2019;12(3):211–217.
24. Uchegbu I, Florence A. Non-ionic surfactant vesicles in drug delivery. *Adv Colloid Interface Sci*. 1995;58:1–55.
25. Mishra P, Yadav R. Novel herbal drug delivery systems and evaluation approaches. *Pharm Rev*. 2017;11(2):89–97.