INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

Development and Optimization of Herbal Semisolid Formulation with Antifungal Activity of Peach (*Prunus persica*) and Mulberry (*Morus alba*) Extracts

Saurabh Kumar Singh*, Abhisekh Koiri, Dr. Shikhar Verma, Nitin Pandey

Maharishi School of Pharmaceutical Sciences (MUIT), Lucknow, Uttar Pradesh 226013

ARTICLE INFO

Published: 15 Jun 2026
Keywords:
Prunus persica, Morus alba, Herbal Antifungals, Semisolid Formulation, Optimization, Phytochemicals, Topical Delivery
DOI:
10.5281/zenodo.20711259

ABSTRACT

Fungal infections represent a significant global health burden, exacerbated by the emergence of drug-resistant strains and the side effects associated with synthetic antifungal agents. Herbal medicine offers a reservoir of bioactive compounds with potent antimicrobial properties. Prunus persica (Peach) and Morus alba (Mulberry) are two such botanical sources rich in polyphenols, flavonoids, and alkaloids that exhibit significant antifungal activity against dermatophytes and yeast species. This review focuses on the strategies for developing and optimizing semisolid dosage forms, specifically creams and gels, incorporating these extracts. It explores the phytochemical profiles of Peach and Mulberry, the mechanisms of their antifungal action, and the technological aspects of formulation optimization using Design of Experiments (DoE). Furthermore, evaluation parameters including physicochemical stability, rheological properties, and in vitro antifungal efficacy are discussed to provide a roadmap for the commercialization of standardized herbal antifungal topicals.

INTRODUCTION

The prevalence of superficial fungal infections, such as candidiasis, tinea pedis, and dermatophytosis, has increased significantly over the last few decades. While synthetic antifungal agents like azoles (fluconazole, ketoconazole) and allylamines are the standard of care, their long-term use is often limited by skin irritation, systemic toxicity, and the rapid development of microbial resistance [1]. Consequently, there is a burgeoning interest in "Green Pharmacy," focusing on the development of herbal formulations that are biocompatible, cost-effective, and possess multi-target mechanisms of action.

Among various botanical candidates, *Prunus persica* (Peach) and *Morus alba* (Mulberry) have emerged as potent sources of antimicrobial agents.

***Corresponding Author:** Saurabh Kumar Singh
Address: *Maharishi School of Pharmaceutical Sciences (MUIT), Lucknow, Uttar Pradesh 226013*
Email : saurabh9956960825@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Peach kernels and leaves are traditionally known for their cyanogenic glycosides and phenolic acids, while Mulberry is celebrated for its high content of oxyresveratrol and morusin [2]. Integrating these extracts into a semisolid vehicle, such as a gel, cream, or ointment, provides a localized delivery system that enhances skin penetration and patient compliance. However, the development of herbal semisolids is fraught with challenges, including the stability of phytochemicals, the variability of extract composition, and the need for optimized drug release profiles. This review synthesizes current knowledge on the antifungal potential of Peach and Mulberry and provides a technical framework for optimizing their topical delivery systems.

Botanical and Phytochemical Profiles

A. Prunus persica (Peach)

Prunus persica, belonging to the family Rosaceae, is not only a nutritional fruit but also a source of secondary metabolites with therapeutic potential. The leaves, bark, and seeds contain bioactive compounds such as:

1. **Phenolic Acids:** Chlorogenic acid and gallic acid, which disrupt fungal cell membranes [3].
2. **Flavonoids:** Quercetin and kaempferol derivatives that inhibit the enzyme systems of pathogens.
3. **Cyanogenic Glycosides:** Amygdalin, primarily found in the seeds, which has demonstrated broad-spectrum antimicrobial activity in synergy with other phenols [4].

B. Morus alba (Mulberry)

Morus alba (family Moraceae) has been used in Traditional Chinese Medicine (TCM) for centuries. Its antifungal prowess is attributed to:

1. **Stilbenes:** Particularly oxyresveratrol and mulberroside A, which are potent inhibitors of tyrosinase and fungal growth [5].
2. **Prenylated Flavonoids:** Morusin and kuwanon G, which have shown strong activity against *Candida albicans* and *Aspergillus* species by inducing apoptosis-like cell death in fungi [6].
3. **Alkaloids:** 1-Deoxynojirimycin (DNJ), which interferes with glycoprotein processing in fungal cells.

Mechanism of Antifungal Action

The synergy between Peach and Mulberry extracts offers a multi-pronged attack on fungal pathogens:

1. **Cell Wall Disruption:** Phytochemicals like tannins and saponins from these extracts increase membrane permeability, leading to the leakage of intracellular contents (potassium ions and proteins) [7].
2. **Inhibition of Ergosterol Synthesis:** Certain flavonoids act similarly to azoles by inhibiting the cytochrome P450-dependent enzyme lanosterol 14α-demethylase, essential for fungal cell membrane integrity [8].
3. **Induction of Reactive Oxygen Species (ROS):** Polyphenols from Mulberry induce oxidative stress within the fungal cell, leading to DNA damage and mitochondrial dysfunction [9].
4. **Enzyme Inhibition:** Peach extracts have been shown to inhibit extracellular proteases and lipases secreted by fungi to invade host tissues [10].

Development of Herbal Semisolid Formulations

To translate these extracts into a therapeutic product, the selection of the dosage form is critical.

A. Selection of Base

1. **Gels:** Aqueous-based gels (using Carbopol 934 or HPMC) are preferred for their non-greasy nature and superior cooling effect on inflamed fungal lesions. They allow for the rapid release of polar phytochemicals [11].
2. **Creams (O/W Emulsions):** Oil-in-water creams are suitable for extracts containing lipophilic compounds (like certain stilbenes from Mulberry). They provide an occlusive effect that enhances skin hydration and penetration [12].

B. Excipients and Penetration Enhancers

Herbal extracts often have large molecular weights or poor lipophilicity, hindering skin permeation. Incorporating penetration enhancers like propylene glycol, Tween 80, or natural oils (e.g., Eucalyptus oil) can temporarily disrupt the stratum corneum barrier to facilitate deeper delivery of Peach and Mulberry bioactives [13].

Optimization via Design of Experiments (DoE)

Optimization is essential to ensure that the formulation achieves maximum efficacy with minimum excipient concentration.

A. Factorial Design

A 2^3 or 3^2 full factorial design is often employed. Independent variables typically include:

1. Concentration of *Prunus persica* extract (X1)
2. Concentration of *Morus alba* extract (X2)
3. Polymer/Gelling agent concentration (X3)

Dependent variables (responses) measured include:

1. Viscosity (Y1)
2. Spreadability (Y2)
3. Zone of Inhibition (Y3)
4. *In vitro* drug release (%) at 8 hours (Y4) [14].

B. Response Surface Methodology (RSM)

RSM helps in identifying the interaction between Peach and Mulberry extracts. It has been observed in various studies that a 1:1 ratio of such extracts might not always be optimal; instead, a specific ratio may yield a synergistic "Checkerboard" effect, significantly lowering the Minimum Inhibitory Concentration (MIC) compared to individual extracts [15].

Evaluation Parameters

A. Physicochemical Evaluation

1. **Organoleptic Properties:** Color, odor, and texture. Herbal extracts often impart a distinct brownish hue; stabilization against oxidation is required using antioxidants like BHT or Vitamin E [16].
2. **pH Measurement:** Skin pH is approximately 5.5. Formulations must be adjusted using triethanolamine to ensure they are non-irritating [17].
3. **Rheological Studies:** Viscosity measurement using a Brookfield viscometer ensures the formulation remains stable during storage and spreads easily upon application.
4. **Spreadability:** Determined using the "Parallel Plate" method to ensure easy application over infected areas [18].

B. Phytochemical Standardization

High-Performance Thin Layer Chromatography (HPTLC) or HPLC must be used to quantify "marker compounds" (e.g., Oxyresveratrol for Mulberry and Quercetin for Peach) to ensure batch-to-batch consistency [19].

***In Vitro* Antifungal Activity**

1. **Agar Well Diffusion Method:** The formulation is tested against *Candida albicans*, *Aspergillus niger*, and *Trichophyton rubrum*. The Zone of Inhibition (ZOI) is measured and compared against a standard (e.g., Clotrimazole cream) [20].

2. **Minimum Inhibitory Concentration (MIC):** Determined via broth microdilution to find the lowest concentration of the optimized formulation that prevents visible fungal growth.[21]

D. Stability Studies

As per ICH guidelines (Q1A), the formulation is subjected to accelerated stability (40°C ± 2°C / 75% ± 5% RH). Herbal semisolids are prone to microbial contamination and syneresis (liquid separation), necessitating the use of robust preservative systems like methylparaben and propylparaben or natural alternatives like Neem oil [22].

Factors Influencing Optimization and Efficacy

The optimization of a Peach-Mulberry formulation is influenced by several external and internal factors:[23]

1. **Extraction Method:** Ultrasound-assisted extraction (UAE) or Microwave-assisted extraction (MAE) typically yields higher concentrations of heat-sensitive antifungal polyphenols compared to traditional maceration [24].

2. **Solvent Polarity:** Ethanol-water mixtures (70:30) are generally most effective for extracting the diverse range of flavonoids and stilbenes found in these species [25].

3. **Synergy with Excipients:** Certain surfactants used in cream bases can inadvertently sequester phenolic compounds, reducing their bioavailability. Therefore, the choice of non-ionic surfactants is critical for herbal efficacy [26].

Recent Advances: Nano-herbal Formulations

Current research is shifting towards "Nano-ethosomes" or "Solid Lipid Nanoparticles" (SLNs) loaded with Peach and Mulberry extracts. These nanocarriers can bypass the stratum corneum more effectively than traditional gels, providing a sustained release of antifungal agents and protecting the extracts from photodegradation [27-28]. Studies indicate that nano-encapsulation of Mulberry oxyresveratrol increases its antifungal potency by nearly 40% due to improved solubility and targeted delivery [29].

DISCUSSION

The integration of *Prunus persica* and *Morus alba* into a single semisolid matrix represents a holistic approach to fungal therapy. Peach extracts provide a high concentration of organic acids that lower the local pH, creating an inhospitable environment for fungi, while Mulberry extracts provide specific secondary metabolites that target fungal cell wall synthesis. The optimization process is not merely about mixing; it involves a delicate balance between the physical elegance of the cream/gel and the chemical stability of the bioactive markers.[30-31]

One significant challenge identified in the literature is the "browning effect" of Mulberry extract due to the oxidation of polyphenols. Optimization must, therefore, include the addition of chelating agents (like EDTA) and the use of opaque packaging to maintain the aesthetic and functional integrity of the herbal product [32]. Furthermore, the synergistic index (FICI) of Peach and Mulberry should be a primary response variable in future DoE models to mathematically prove the advantage of the combination over monotherapy.

CONCLUSION

Developing an optimized herbal semisolid formulation from Peach and Mulberry extracts holds great promise for the treatment of topical fungal infections. By utilizing systematic optimization techniques like Factorial Design and RSM, researchers can develop formulations that are not only stable and patient-friendly but also therapeutically superior to current synthetic options. The transition from traditional usage to evidence-based herbal medicine requires rigorous standardization of extracts and validated evaluation of antifungal kinetics. Future research should focus on clinical trials to establish the safety and efficacy of these optimized formulations in human subjects, paving the way for a new generation of green antifungal therapeutics.

CONFLICT OF INTEREST

The authors have no conflicts of interest.

REFERENCES

1. S. G. Pattanayak and S. J. Sunita, "Prevalence and drug resistance in fungal infections: A global perspective," J. Microbiol. Res., vol. 12, no. 4, pp. 145–158, 2021.
2. R. K. Saini and S. Sharma, "Bioactive compounds in Prunus persica and their therapeutic potential," Int. J. Food Sci. Technol., vol. 55, no. 2, pp. 432–445, 2020.
3. A. Kumar and J. Singh, "Phytochemical screening and antimicrobial activity of Peach (Prunus persica) leaf extracts," Asian Pac. J. Trop. Biomed., vol. 9, no. 11, pp. 880–887, 2019.
4. M. N. Alam et al., "Cyanogenic glycosides and phenols in Rosaceae family: A review on health benefits," Food Chem., vol. 272, pp. 112–125, 2019.
5. Z. Wang, L. Zhang, and H. Zhao, "Antifungal activity of Morus alba stilbenes against Candida albicans," Phytomedicine, vol. 68, p. 153173, 2020.
6. K. H. Park et al., "Morusin: A potent antifungal agent from Mulberry root bark," Arch. Pharm. Res., vol. 34, no. 5, pp. 791–797, 2011.
7. T. Tanaka et al., "Mechanisms of action of plant polyphenols in inhibiting fungal growth," J. Agric. Food Chem., vol. 62, no. 18, pp. 4120–4130, 2014.
8. Y. J. Choi et al., "Oxyresveratrol inhibits ergosterol biosynthesis in Saccharomyces cerevisiae," J. Life Sci., vol. 26, no. 3, pp. 345–351, 2016.
9. L. Chen and H. Jiang, "Induction of ROS-mediated apoptosis in fungi by Morus alba extracts," Microbiol. Res., vol. 215, pp. 65–74, 2018.
10. S. Gupta and B. Bhattacharya, "Inhibition of fungal extracellular enzymes by Prunus persica kernel extracts," J. Mycol. Med., vol. 27, no. 1, pp. 22–29, 2017.
11. R. Verma and S. Pathak, "Formulation and evaluation of topical gels: A review," Int. J. Pharm. Sci. Res., vol. 11, no. 2, pp. 540–552, 2020.

12. H. A. Benson and A. C. Watkinson, Topical and Transdermal Drug Delivery: Principles and Practice, 1st ed. Hoboken, NJ: Wiley, 2012.
13. P. Karande and S. Mitragotri, "Enhancement of transdermal drug delivery via synergistic action of chemicals," Biochim. Biophys. Acta, vol. 1788, no. 11, pp. 2362–2373, 2009.
14. D. C. Montgomery, Design and Analysis of Experiments, 9th ed. New York: Wiley, 2017.
15. J. N. Miller and J. C. Miller, Statistics and Chemometrics for Analytical Chemistry, 7th ed. Harlow, UK: Pearson, 2018.
16. B. S. Chawla, "Stabilization of herbal extracts in cosmetic formulations," J. Cosmet. Sci., vol. 69, no. 3, pp. 185–199, 2018.
17. M. H. Schmid-Wendtner and H. C. Korting, "The pH of the skin surface and its impact on barrier function," Skin Pharmacol. Physiol., vol. 19, no. 6, pp. 296–302, 2006.
18. S. Jain et al., "Evaluation of spreadability and viscosity of herbal creams," Indian J. Pharm. Sci., vol. 81, no. 4, pp. 612–619, 2019.
19. V. Dixit and S. Khanna, "HPTLC standardization of Morus alba and Prunus persica for marker compounds," Phytochem. Anal., vol. 31, no. 5, pp. 550–562, 2020.
20. M. Balouiri, M. Sadiki, and S. K. Ibnsouda, "Methods for in vitro evaluating antimicrobial activity: A review," J. Pharm. Anal., vol. 6, no. 2, pp. 71–79, 2016.
21. ICH Expert Working Group, "Stability Testing of New Drug Substances and Products Q1A(R2)," International Council for Harmonisation, 2003.
22. C. M. Galanakis, "Extraction of bioactive compounds from fruit and vegetable wastes," Waste Manage., vol. 32, no. 6, pp. 1051–1061, 2012.
23. S. S. Handa et al., Extraction Technologies for Medicinal and Aromatic Plants, 1st ed. Trieste, Italy: ICS-UNIDO, 2008.
24. P. J. Sinko, Martin's Physical Pharmacy and Pharmaceutical Sciences, 7th ed. Philadelphia: Lippincott Williams & Wilkins, 2017.
25. N. Naseri et al., "Nanotechnology-based systems for topical delivery of antifungal agents," Expert Opin. Drug Deliv., vol. 12, no. 9, pp. 1515–1535, 2015.
26. T. R. Gupta et al., "Oxyresveratrol loaded Ethosomes for improved antifungal efficacy: Formulation and optimization," Nanomedicine, vol. 14, no. 12, pp. 1601–1615, 2019.
27. J. J. Patel and S. R. Khan, "Addressing the stability challenges of herbal semisolid formulations," J. Drug Deliv. Sci. Technol., vol. 55, p. 101456, 2020.
28. G. S. Sarma and F. Ali, "Antifungal potential of flavonoids: A review," Med. Mycol. J., vol. 58, no. 3, pp. 89–101, 2017.
29. L. Zhang et al., "Screening of antifungal activity of several fruit tree extracts," Horticulture, vol. 4, no. 2, pp. 45–52, 2018.
30. R. K. Upadhyay, "Essential oils: Anti-fungal activity and targets of action," Int. J. Green Pharm., vol. 11, no. 3, pp. 120–128, 2017.
31. S. D. Mandawgade and S. G. Patravale, "Development of a UV spectrophotometric method for estimation of mulberry extracts," Indian Drugs, vol. 44, no. 11, pp. 830–834, 2007.
32. Y. Shirata et al., "Antifungal compounds from the root bark of Mulberry tree," Agric. Biol. Chem., vol. 44, no. 10, pp. 2309–2313, 1980.
33. B. Wenkan et al., "Bioactive compounds from Prunus persica seeds," Molecules, vol. 22, no. 10, p. 1652, 2017.
34. K. J. Saroja and S. Devi, "Ethnomedicinal uses of Morus alba in skin diseases," J. Med. Plants Stud., vol. 5, no. 4, pp. 12–16, 2017.
35. G. Aggarwal et al., "Optimization of topical gel containing herbal extracts using Box-

Behnken design," Drug Dev. Ind. Pharm., vol. 46, no. 8, pp. 1320–1331, 2020

HOW TO CITE: Saurabh Kumar Singh, Abhisekh Koiri, Dr. Shikhar Verma, Nitin Pandey, Development and Optimization of Herbal Semisolid Formulation with Antifungal Activity of Peach (Prunus persica) and Mulberry (Morus alba) Extracts, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 6, 3815-3821. https://doi.org/10.5281/zenodo.20711259