

The Review on Formulation and Evaluation of An Herbal Foot Cream for Cracked Heels Using Papaya and Mahua Extract

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ABSTRACT

Rough patches on feet sometimes split open - these dry spots show up quietly yet cause pain, splits, or even infections when overlooked. Standing too long, going barefoot, harsh weather, or skipping regular foot attention increases chances they will form. Many store creams rely on lab-made scrubs combined with fake hydrators, which might trigger reactions, discomfort, or weakened skin after multiple applications. Because of drawbacks like these, solutions drawn from plants have attracted interest, offering gradual healing using ingredients found in nature. Papaya leaves offer natural substances - papain among them, along with flavonoids, tinctures, alkaloids - that soften hardened skin surfaces, slow dangerous microorganisms, yet aid recovery of damaged areas. In contrast, *Madhuca longifolia* works through saponins, triterpenoids, polyphenolics, easing inflammation while fostering new cellular development. When included in creams meant for cracked, parched heels, these plant-based agents improve moisture retention within skin layers, speed up removal of aged cells, reduce healing duration in harmed regions, at the same time limiting unwanted microbial buildup. This piece examines heel cracks as they form, then shifts toward plant-based solutions tied to healthy skin. Following that, attention moves to how herbal lotions for feet are built. Soon after comes discussion around tests checking if products stay stable, safe, long-term performance. Progression of discomfort through stages appears in later parts.

Keywords: Cracked heels, herbal foot cream, *Carica papaya*, *Madhuca longifolia*, wound healing, polyherbal formulation.

INTRODUCTION

1.1 Skin Structure and Function of the Heel

The skin is the largest organ of the human body and serves as a primary protective barrier against environmental insults, microbial invasion, and mechanical stress¹. Structurally, the skin consists of three major layers: the epidermis, dermis, and hypodermis². The epidermis of the heel region is significantly thicker compared to other body parts due to continuous exposure to pressure, friction, and weight bearing³.

The stratum corneum, which is the outermost layer of the epidermis, plays a critical role in maintaining skin hydration and integrity⁴. It contains corneocytes

embedded in a lipid matrix composed mainly of ceramides, cholesterol, and free fatty acids⁵. Disruption of this lipid matrix results in excessive transepidermal water loss (TEWL)⁶, leading to dryness and loss of elasticity, which are major contributing factors to cracked heels⁷.

1.2 Cracked Heels (Heel Fissures): Definition and Clinical Features

Cracked heels, also known as heel fissures, refer to linear breaks or splits in the thickened skin of the heel, often accompanied by dryness, scaling, and hyperkeratosis⁸. Initially, the condition presents as dry and flaky skin; however, with continued stress and lack of treatment, deep fissures may develop, causing pain, bleeding, and difficulty in walking⁹.

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In severe cases, cracked heels may become portals of entry for pathogenic microorganisms, leading to secondary bacterial or fungal infections¹⁰. Individuals with diabetes mellitus, obesity, psoriasis, and eczema

are at higher risk of developing chronic and complicated heel fissures due to impaired skin barrier function and delayed wound healing¹¹.



Fig. No. 1 Stages of Heel Skin Damage

1.3 Etiology and Risk Factors of Cracked Heels

Several intrinsic and extrinsic factors contribute to the development of cracked heels. Common etiological factors include prolonged standing, walking barefoot, wearing open-back footwear, exposure to dry or cold climates, and inadequate foot hygiene¹². Nutritional deficiencies, particularly of essential fatty acids, vitamins A and E, and zinc, also impair skin regeneration and hydration, increasing susceptibility to heel fissures¹³. Systemic conditions such as diabetes and hypothyroidism further exacerbate the condition by reducing skin elasticity and delaying tissue repair¹⁴.

1.4 Limitations of Conventional Foot Creams

Conventional foot creams commonly contain synthetic keratolytic agents such as salicylic acid, urea, lactic acid, and alpha-hydroxy acids, which help in removing dead skin cells and softening hyperkeratotic skin¹⁵. Although effective, prolonged use of these agents may cause skin irritation, burning sensation, erythema, and allergic reactions, particularly in individuals with sensitive skin¹⁶. Moreover, synthetic preservatives, fragrances, and parabens used in commercial formulations may pose safety concerns with long-term application¹⁷. These limitations have driven research toward the development of herbal foot creams that utilize plant-based bioactive compounds

with better safety profiles and added therapeutic benefits¹⁸.

1.5 Need for Herbal Foot Creams

Herbal medicines have been used traditionally for centuries in the management of skin disorders due to their natural origin, biocompatibility, and multifunctional pharmacological activities¹⁹. Plant extracts contain a wide range of secondary metabolites such as flavonoids, tannins, saponins, alkaloids, and phenolic compounds that exhibit wound-healing, anti-inflammatory, antimicrobial, and antioxidant effects²⁰. The incorporation of herbal extracts into topical formulations like creams allows for localized drug delivery, enhanced patient compliance, and reduced systemic side effects²¹. Papaya and mahua leaves, in particular, have been widely reported in ethnomedicine for treating skin cracks, wounds, and inflammation, making them promising candidates for polyherbal foot cream formulations^{22,23}.

2. ROLE OF HERBAL MEDICINES IN DERMATOLOGICAL THERAPY

Herbal medicines have played a vital role in the management of skin disorders since ancient times and continue to gain importance in modern dermatological therapy due to their safety, efficacy, and cultural acceptance²⁴. Traditional systems of medicine such as Ayurveda, Unani, Siddha, and Traditional Chinese Medicine extensively document the use of medicinal plants for treating skin ailments including wounds, cracks, ulcers, burns, infections, and inflammatory conditions²⁵. Skin disorders account for a significant proportion of global disease burden, affecting quality of life and psychological well-being²⁶. Synthetic dermatological preparations, though effective, are often associated with adverse effects such as skin irritation, allergic reactions, and long-term toxicity²⁷. These drawbacks have encouraged a shift toward herbal formulations, which offer multi-targeted therapeutic action with minimal side effects²⁸. Herbal drugs contain a complex mixture of phytochemicals such as flavonoids, tannins, phenolic acids, saponins, terpenoids, and alkaloids that act synergistically to promote wound healing, reduce inflammation, and protect against microbial invasion²⁹. Unlike synthetic drugs that target a single pathway, herbal medicines exert holistic effects by modulating multiple biological mechanisms involved in skin repair³⁰. In cracked heel conditions, herbal remedies provide emollient action to restore skin hydration, keratolytic activity to remove dead skin layers, antimicrobial protection to prevent infection, and antioxidant support to enhance tissue regeneration³¹. These properties make herbal foot creams particularly suitable for long-term use without compromising skin safety³². Furthermore, the incorporation of herbal extracts into topical dosage forms such as creams, gels, and ointments improves patient compliance due to ease of application, pleasant sensory attributes, and enhanced cosmetic acceptability³³. Herbal foot creams are especially advantageous in rural and economically constrained populations where access to expensive dermatological treatments is limited³⁴.

3. PAPAYA (*Carica papaya*)

3.1 Botanical Description and Distribution

Carica papaya L., commonly known as papaya, belongs to the family Caricaceae and is widely

cultivated in tropical and subtropical regions across the world, including India, Sri Lanka, Indonesia, and parts of Africa and South America³⁵. The plant is a fast-growing, herbaceous tree with a hollow stem, large palmately lobed leaves, and milky latex³⁶.

Papaya fruit are large, deeply lobed, and rich in bioactive constituents, making them a valuable source of medicinal compounds³⁷. Traditionally, papaya fruit have been used for treating wounds, burns, skin infections, ulcers, and inflammatory conditions³⁸.

3.2 Phytochemical Constituents of Papaya fruit

Papaya fruit contain a wide range of phytochemicals that contribute to their therapeutic potential. Major constituents include proteolytic enzymes such as papain and chymopapain, flavonoids, tannins, saponins, alkaloids, glycosides, and phenolic compounds³⁹. Papain, a cysteine protease enzyme, plays a crucial role in the removal of necrotic tissue and promotes wound debridement, thereby accelerating healing in cracked and damaged skin⁴⁰. Flavonoids and phenolic compounds exhibit strong antioxidant activity, which protects skin cells from oxidative stress and supports tissue regeneration⁴¹. Tannins present in papaya fruit exert astringent action that helps in tightening the skin and reducing excessive moisture loss, an important factor in preventing heel fissures⁴². Additionally, saponins contribute to antimicrobial activity and enhance penetration of active constituents through the skin barrier⁴³.

3.3 Pharmacological Activities of Papaya Relevant to Cracked Heels

Papaya fruit extract has been extensively studied for its wound-healing activity. Experimental studies have demonstrated that topical application of papaya extract enhances collagen synthesis, increases tensile strength of the skin, and accelerates epithelialization⁴⁴. These effects are particularly beneficial in treating cracked heels where skin integrity is compromised.

The antimicrobial activity of papaya fruit against bacteria and fungi such as *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans* has been well documented⁴⁵. This property is essential in preventing secondary infections in deep heel fissures.



⁴⁶. Papaya fruit extract also exhibits anti-inflammatory activity by inhibiting pro-inflammatory mediators such as prostaglandins and cytokines, thereby reducing pain, redness, and swelling associated with cracked heels ⁴⁷. The combined keratolytic and emollient action of papaya aids in softening hardened skin and facilitating removal of dead cells ⁴⁸.

3.4 Use of Papaya in Topical Formulations

Several studies have reported the successful incorporation of papaya fruit extract into topical formulations such as creams, gels, and ointments for wound healing and antifungal applications ⁴⁹. These formulations demonstrated acceptable physicochemical properties, stability, and enhanced therapeutic efficacy compared to conventional treatments ⁵⁰. Papaya-based topical products are particularly advantageous due to their natural origin, affordability, and minimal side effects, making them suitable for chronic skin conditions like cracked heels ⁵¹. The enzymatic activity of papaya supports gentle exfoliation without causing irritation, which is often observed with synthetic keratolytic agents ⁵².

4. MAHUA (*Madhuca longifolia*)

4.1 Botanical Description and Distribution

Madhuca longifolia (Koenig) J.F. Macbr., commonly known as Mahua, belongs to the family Sapotaceae and is widely distributed throughout the tropical regions of India, Sri Lanka, Nepal, and parts of Southeast Asia ⁵³. The tree is medium to large in size, evergreen or semi-evergreen, and is traditionally valued for its flowers, seeds, bark, and leaves in indigenous medicine ⁵⁴. Mahua leaves are thick, leathery, and rich in bioactive phytoconstituents that make them suitable for treating various skin ailments such as wounds, ulcers, eczema, cracked skin, and inflammatory conditions ⁵⁵. In traditional Indian medicine, mahua leaves are applied externally as poultices to heal cracks and wounds of the feet, highlighting their relevance in cracked heel management ⁵⁶.

4.2 Phytochemical Constituents of Mahua Leaves

Mahua leaves contain a wide range of secondary metabolites including flavonoids, triterpenoids,

saponins, tannins, glycosides, and polyphenolic compounds ⁵⁷. These phytochemicals contribute significantly to the plant's therapeutic activities and skin-protective properties ⁵⁸.

Flavonoids present in mahua leaves act as potent antioxidants by scavenging free radicals and reducing oxidative stress at the site of skin damage ⁵⁹. Triterpenoids and saponins contribute to anti-inflammatory and wound-healing activities by enhancing fibroblast proliferation and collagen deposition ⁶⁰.

Tannins present in mahua leaves exert astringent effects that help in tightening the skin and reducing excessive moisture loss, thereby preventing further cracking of the heels ⁶¹. Additionally, polyphenolic compounds provide antimicrobial protection against common skin pathogens, reducing the risk of secondary infections in heel fissures ⁶².

4.3 Pharmacological Activities of Mahua Relevant to Cracked Heels

Mahua leaf extract has demonstrated significant wound-healing activity in experimental models by accelerating epithelialization, improving tensile strength, and enhancing collagen synthesis ⁶³. These properties are crucial for repairing deep heel fissures and restoring skin integrity ⁶⁴.

Anti-inflammatory activity of mahua leaves is attributed to inhibition of inflammatory mediators such as histamine, prostaglandins, and cytokines, resulting in reduced pain, swelling, and redness at the affected site ⁶⁵. This is particularly beneficial in cracked heels where inflammation often accompanies fissure formation ⁶⁶.

Mahua leaves also exhibit antimicrobial activity against both Gram-positive and Gram-negative bacteria, as well as certain fungal strains, which supports their use in preventing infections in cracked and bleeding heels ⁶⁷. Furthermore, the emollient nature of mahua leaves helps in restoring skin softness and elasticity, reducing dryness and scaling ⁶⁸.



4.4 Traditional and Ethnomedicinal Uses of Mahua in Skin Disorders

In Ayurveda and folk medicine, mahua leaves are traditionally used for treating skin cracks, ulcers, burns, and inflammatory conditions ⁶⁹. Leaf paste or decoction is commonly applied externally to wounds and cracked skin to promote healing and relieve pain ⁷⁰. Ethnobotanical surveys have documented the use of mahua leaf preparations for treating heel fissures among tribal populations, emphasizing its long-standing role in foot care ⁷¹. The use of mahua leaves in topical formulations aligns with traditional knowledge and provides a scientific basis for developing herbal foot creams ⁷².

5. RATIONALE FOR POLYHERBAL FOOT CREAM USING PAPAYA AND MAHUA

The concept of polyherbal formulation is based on the principle that a combination of herbs can produce superior therapeutic effects compared to individual herbs due to synergistic interactions among

phytoconstituents ⁷³. In the management of cracked heels, multiple pathological factors such as dryness, hyperkeratosis, inflammation, microbial infection, and delayed wound healing must be addressed simultaneously ⁷⁴.

Papaya extract provides keratolytic, antimicrobial, and wound-debriding effects due to the presence of papain and flavonoids ⁷⁵. In contrast, mahua leaf extract offers strong emollient, anti-inflammatory, and skin-repair properties ⁷⁶. The combination of these two herbal extracts ensures comprehensive management of cracked heels by softening hardened skin, removing dead cells, restoring moisture, reducing inflammation, and accelerating tissue regeneration ⁷⁷.

Furthermore, the polyherbal approach minimizes the concentration of individual extracts required, thereby reducing the risk of skin irritation while enhancing overall efficacy ⁷⁸. This makes the papaya–mahua herbal foot cream suitable for long-term use and repeated application without adverse effects ⁷⁹.



Fig. No .2 Synergistic Mechanism of Papaya + Mahua

6. FORMULATION OF HERBAL FOOT CREAM

6.1 Selection of Dosage Form

Topical creams are one of the most preferred dosage forms for the treatment of cracked heels due to their ease of application, good patient compliance, and ability to deliver active ingredients directly to the affected site ⁸⁰. Creams provide both therapeutic and

cosmetic benefits by moisturizing the skin, improving texture, and promoting healing ⁸¹.

Herbal foot creams are generally formulated as oil-in-water (O/W) or water-in-oil (W/O) emulsions. O/W creams are preferred for cracked heels as they are non-greasy, easily washable, and provide better hydration to dry and fissured skin ⁸².

6.2 Selection of Herbal Ingredients

Papaya (*Carica papaya*) Extract

Papaya extract is incorporated for its keratolytic, antimicrobial, wound-healing, and anti-inflammatory properties ⁸³. The presence of papain enzyme facilitates gentle exfoliation of dead skin cells, aiding in the repair of cracked heels ⁸⁴.

Mahua (*Madhuca longifolia*) Leaf Extract

Mahua leaf extract is included due to its emollient, anti-inflammatory, antioxidant, and skin-regenerating properties ⁸⁵. It helps restore skin elasticity and so fitness, preventing further fissure formation ⁸⁶.

The combination of these two extracts ensures synergistic action for comprehensive management of cracked heels ⁸⁷.

6.3 Selection of Excipients

Excipients play a crucial role in determining the stability, consistency, spreadability, and therapeutic efficacy of the cream formulation ⁸⁸. Commonly used excipients in herbal foot creams include:

1. Emulsifying agents (e.g., beeswax, cetostearyl alcohol): Maintain emulsion stability and consistency ⁸⁹.
2. Emollients (e.g., liquid paraffin, glycerin): Improve skin hydration and softness ⁹⁰.
3. Preservatives (e.g., methyl paraben): Prevent microbial contamination during storage ⁹¹.
4. Humectants: Retain moisture and prevent excessive dryness ⁹².

5. Selection of safe and skin-friendly excipients is essential to avoid irritation, especially in damaged heel skin ⁹³.

6.4 Extraction of Herbal Materials

The therapeutic efficacy of herbal formulations largely depends on the extraction method used to isolate bioactive constituents ⁹⁴. Papaya and mahua leaves are usually shade-dried, powdered, and extracted using solvents such as ethanol, methanol, or hydroalcoholic mixtures ⁹⁵.

Maceration and Soxhlet extraction are commonly employed techniques for obtaining concentrated extracts ⁹⁶. Ethanolic extracts are preferred due to their ability to dissolve a wide range of phytoconstituents and their suitability for topical formulations ⁹⁷. After extraction, the solvent is removed under reduced pressure using a rotary evaporator, and the dried extract is stored in airtight containers to preserve stability ⁹⁸.

6.5 General Method of Preparation of Herbal Foot Cream

The herbal foot cream is prepared by the fusion method, where the oil phase and aqueous phase are heated separately and then combined with continuous stirring ⁹⁹.

1. Oil phase ingredients such as emulsifying wax, cetostearyl alcohol, and liquid paraffin are melted at 70–75°C ¹⁰⁰.
2. Aqueous phase containing distilled water, preservatives, and herbal extracts is heated to the same temperature ¹⁰¹.
3. The aqueous phase is slowly added to the oil phase with continuous stirring to form a uniform emulsion ¹⁰².
4. The mixture is allowed to cool with gentle stirring until a smooth cream is obtained ¹⁰³.
5. This method ensures uniform distribution of herbal extracts and stable cream consistency ¹⁰⁴.

7. EVALUATION OF HERBAL FOOT CREAM



7.1 Physical Appearance

The prepared herbal foot cream is visually examined for color, odor, homogeneity, and texture ¹⁰⁵. Absence of phase separation and grittiness indicates good formulation quality ¹⁰⁶.

7.2 pH Determination

The pH of the cream is measured using a digital pH meter after dispersing a known quantity of cream in distilled water ¹⁰⁷. The ideal pH range for topical creams is between 5.5 and 7.0 to match skin pH and prevent irritation ¹⁰⁸.

7.3 Spreadability

Spreadability determines the ease with which the cream can be applied over the skin surface ¹⁰⁹. It is measured using the glass slide method, and good spreadability ensures better patient compliance ¹¹⁰.

7.4 Viscosity

Viscosity affects the flow properties and application behavior of the cream ¹¹¹. It is measured using a Brookfield viscometer, and optimum viscosity ensures that the cream remains on the heel surface for a longer duration ¹¹².

7.5 Washability

Washability is assessed by applying the cream on skin and washing with running water ¹¹³. Easily washable creams are preferred for routine foot care ¹¹⁴.

7.6 Stability Studies

Stability testing is conducted by storing the formulation at different temperature conditions and observing changes in physical properties over time ¹¹⁵. Stable formulations ensure consistent therapeutic efficacy throughout shelf life ¹¹⁶.

Parameter	Instrument/Method	Desired Result
Appearance	Visual check	Smooth, uniform, no grittiness
pH	Digital pH meter	5.5–7.0
Spreadability	Slip & drag method	Easy spreading
Viscosity	Brookfield viscometer	Medium-high
Washability	Water rinsing test	Easily washable
Stability	1–3 month storage	No phase separation

Table : Evaluation Parameters for Herbal Foot Creams

8. ANTIMICROBIAL AND WOUND-HEALING RELEVANCE IN CRACKED HEELS

Cracked heels are frequently complicated by microbial colonization due to disruption of the skin barrier, which facilitates the entry of pathogenic bacteria and fungi ¹¹⁷. Common microorganisms associated with infected heel fissures include *Staphylococcus aureus*, *Streptococcus* species, and *Candida albicans* ¹¹⁸. Therefore, an effective foot cream should not only moisturize and heal the skin but also provide antimicrobial protection ¹¹⁹.

Papaya leaf extract exhibits broad-spectrum antimicrobial activity against Gram-positive, Gram-negative, and fungal pathogens due to the presence of papain, alkaloids, and phenolic compounds ¹²⁰. These

constituents damage microbial cell membranes, inhibit enzyme activity, and prevent microbial colonization at wound sites ¹²¹.

Mahua leaf extract also demonstrates antimicrobial efficacy attributed to tannins, flavonoids, and saponins, which interfere with microbial protein synthesis and cell wall integrity ¹²². The combined antimicrobial action of papaya and mahua extracts enhances protection against secondary infections in cracked heels ¹²³.

Wound healing is a complex biological process involving inflammation, proliferation, collagen synthesis, and tissue remodeling ¹²⁴. Papaya leaf extract accelerates wound healing by promoting debridement, collagen deposition, and epithelial regenerati



on¹²⁵. Mahua leaf extract complements this action by reducing inflammation, enhancing fibroblast activity, and restoring skin elasticity¹²⁶. The polyherbal formulation thus provides a holistic wound-healing approach¹²⁷.

9. COMPARATIVE REVIEW OF PREVIOUS STUDIES ON HERBAL FOOT CREAMS

Several studies have reported the formulation and evaluation of herbal foot care products using plant extracts such as neem, aloe vera, turmeric, papaya, and other medicinal plants¹²⁸. These studies consistently demonstrate that herbal foot creams improve skin hydration, reduce fissure depth, enhance healing rate, and show good patient acceptability¹²⁹.

Mukkirwar et al. developed a herbal foot crack gel containing natural extracts and reported significant improvement in cracked heel conditions without irritation¹³⁰. Similarly, Patil et al. formulated an antifungal cream using papaya leaf extract and observed enhanced antimicrobial activity and good physicochemical stability¹³¹.

Compared to single-herb formulations, polyherbal creams exhibited superior efficacy due to synergistic action among phytoconstituents¹³². The combination of papaya and mahua leaf extracts addresses multiple pathological factors of cracked heels simultaneously, making it more effective than conventional single-agent formulations¹³³.

10. SAFETY, STABILITY, AND REGULATORY CONSIDERATIONS

Safety is a critical aspect of topical herbal formulations, particularly for damaged skin such as cracked heels¹³⁴. Herbal foot creams prepared using standardized extracts and pharmaceutically acceptable excipients have shown minimal risk of irritation or hypersensitivity reactions¹³⁵.

Stability studies ensure that the formulation maintains its physical appearance, pH, viscosity, and therapeutic efficacy throughout its shelf life¹³⁶. Herbal creams formulated with proper emulsifiers and preservatives demonstrate acceptable stability under room temperature and accelerated storage conditions¹³⁷.

According to WHO and regulatory guidelines, herbal cosmetic formulations must comply with quality, safety, and efficacy standards before commercialization¹³⁸. Standardization of herbal extracts, microbial limit testing, and labeling requirements are essential for ensuring consumer safety¹³⁹.

11. FUTURE PROSPECTS

The growing demand for natural and herbal skincare products provides significant opportunities for the development of herbal foot creams¹⁴⁰. Further research can focus on optimizing extract concentrations, exploring novel natural excipients, and conducting clinical studies to establish long-term efficacy and safety¹⁴¹.

Advanced drug delivery approaches such as nano-emulsions and liposomal herbal creams may further enhance skin penetration and therapeutic outcomes in cracked heel treatment¹⁴². Integration of traditional knowledge with modern pharmaceutical technology will play a key role in the future development of herbal foot care products¹⁴³.

12. CONCLUSION

Cracked heels are a common yet often neglected dermatological condition that can significantly affect quality of life. Conventional treatments, although effective, are associated with limitations such as irritation and long-term safety concerns. Herbal foot creams provide a safe, effective, and economical alternative for managing cracked heels.

Papaya (*Carica papaya*) leaf extract offers keratolytic, antimicrobial, and wound-healing properties, while mahua (*Madhuca longifolia*) leaf extract provides emollient, anti-inflammatory, and skin-repair effects. The polyherbal foot cream formulation combining these extracts ensures synergistic action, improved therapeutic efficacy, and enhanced patient compliance.

Based on the reviewed literature, herbal foot creams formulated with papaya and mahua leaf extracts show strong potential as effective topical remedies for cracked heels and represent a promising approach in herbal dermatological therapy.



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