

Pharmacological Evaluation of Selected Indian Herbal Extract for Wound Healing Activity

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Abstract: *Wound healing is a complex biological process involving tissue repair, inflammation, collagen formation, angiogenesis, and epithelialization. Delayed wound healing may occur because of infection, oxidative stress, diabetes, poor nutrition, and tissue damage. Herbal medicines have gained considerable importance due to their safety, affordability, availability, and minimal side effects compared with synthetic medicines.*

The present study focuses on the pharmacological evaluation of selected Indian herbal extracts for wound healing activity. Medicinal plants such as Aloe vera, Curcuma longa (Turmeric), and Azadirachta indica (Neem) were selected based on their traditional and scientific importance in wound management. The plant materials were collected, shade dried, powdered, and extracted using suitable solvents by Soxhlet extraction method.

The obtained extracts were subjected to phytochemical screening for the identification of alkaloids, flavonoids, tannins, saponins, terpenoids, glycosides, and phenolic compounds. Herbal formulations such as ointment or gel were prepared and evaluated for various physicochemical parameters including pH, spreadability, viscosity, homogeneity, stability, and drug content. Pharmacological evaluation of wound healing activity was carried out using excision and incision wound models. Parameters such as percentage wound contraction, epithelialization period, tensile strength, collagen synthesis, and histopathological changes were studied. Antioxidant and antimicrobial activities were also evaluated to support the mechanism of wound healing.

The study demonstrated significant wound healing potential of selected Indian herbal extracts due to their antimicrobial, antioxidant, anti-inflammatory, and collagen promoting properties. These findings support the development of herbal wound healing formulations as safe and effective alternatives to synthetic drugs.

Keywords: Wound Healing, Herbal Extracts, Pharmacological Evaluation, Aloe vera, Turmeric, Neem, Herbal Formulation, Antioxidant Activity

I. INTRODUCTION

Wound healing is an essential physiological process that restores the integrity and function of damaged tissues following injury. It involves a highly coordinated sequence of cellular, biochemical, and molecular events including hemostasis, inflammation, proliferation, collagen synthesis, angiogenesis, epithelialization, and tissue remodeling. Delayed wound healing remains a major healthcare concern worldwide due to microbial infections, diabetes mellitus, oxidative stress, malnutrition, vascular insufficiency, and immune disorders. Conventional wound healing agents and antibiotics are often associated with high cost, microbial resistance, adverse effects, and limited tissue regeneration. Therefore, there is growing scientific interest in herbal medicines as safer and cost-effective alternatives for wound management.



II. NEED OF STUDY

1. Increasing incidence of chronic wounds and infections.
2. High cost and side effects of synthetic wound healing drugs.
3. Development of antibiotic resistance.
4. Demand for natural and safer medicines.
5. Scientific validation of traditional herbal medicines.
6. Availability of medicinal plants in India.
7. Need for economical wound healing formulations.

III. AIM & OBJECTIVE

Aim :

To evaluate the pharmacological wound healing activity of selected Indian herbal extracts by using experimental wound models and to develop an effective herbal formulation with antimicrobial, antioxidant, and tissue regenerative properties for wound management.

OBJECTIVES

1. To collect and authenticate medicinal plants.
2. To prepare herbal extracts using suitable extraction methods.
3. To perform phytochemical screening of extracts.
4. To formulate herbal ointment or gel.
5. To evaluate physicochemical properties of formulation.
6. To evaluate wound healing activity using pharmacological models.
7. To compare herbal formulation with standard marketed formulation.
8. To study antimicrobial and antioxidant activities.
9. To perform histopathological evaluation.
10. To determine safety and stability of formulation.

IV. REVIEW OF LITERATURE

1. Herbal Medicines in Wound Healing

Medicinal plants have been used traditionally for treating wounds due to their antimicrobial and tissue regenerating properties.

2. Aloe vera

Contains glucomannan, vitamins, amino acids, anthraquinones, and polysaccharides.

Actions:

- Promotes fibroblast proliferation
- Increases collagen synthesis
- Enhances epithelialization
- Provides moisturizing effect
- Curcuma longa (Turmeric)

Contains curcumin as major active constituent.

Actions:

- Anti-inflammatory activity
- Antioxidant activity
- Antimicrobial activity
- Accelerates tissue repair



3. Azadirachta indica (Neem)

Contains nimbin, azadirachtin, quercetin. Actions:

- Antibacterial activity
- Antifungal activity
- Anti-inflammatory effect

The wound healing potential of neem is mainly attributed to:

- Antimicrobial activity
- Anti-inflammatory action
- Promotion of collagen synthesis
- Antioxidant property
- Enhanced epithelialization

2. Aloe Vera



Aloe vera is extensively used in herbal medicine for burns, wounds, cuts, and skin disorders. The mucilaginous gel present inside aloe leaves contains polysaccharides, vitamins, enzymes, amino acids, glycoproteins, and minerals. Numerous pharmacological investigations revealed that aloe vera gel significantly enhances wound contraction and reduces healing time. Studies conducted on burn wound models showed rapid epithelialization and increased collagen deposition following topical application of aloe vera gel. Acemannan, a major polysaccharide of aloe vera, stimulates macrophage activation and growth factor production which play vital roles in tissue repair. Aloe vera also increases fibroblast proliferation and promotes angiogenesis.

Researchers observed that aloe vera-treated wounds showed:

- Increased hydroxyproline content
- Enhanced granulation tissue formation
- Reduced inflammation
- Faster epithelialization
- Improved collagen maturation

The antimicrobial and moisturizing effects of aloe vera also help maintain a favorable wound environment.

3. Curcuma longa (Turmeric)



Curcuma longa has been traditionally used in India as an antiseptic and wound healing agent. Curcumin, the major active constituent, exhibits powerful antioxidant and anti-inflammatory activities. Several experimental studies demonstrated that topical application of turmeric extract accelerates wound contraction and collagen synthesis. Curcumin modulates various molecular targets involved in inflammation and tissue repair. Researchers reported that curcumin enhances:

- Fibroblast migration
- Granulation tissue formation
- Angiogenesis
- Collagen deposition
- Re-epithelialization

Curcumin also inhibits lipid peroxidation and scavenges free radicals generated during inflammation. In infected wound models, turmeric extract showed antibacterial activity against several wound pathogens. Histological studies revealed improved dermal regeneration and organized collagen fibers in curcumin-treated wounds.

4. *Centella asiatica* (Gotu Kola)



Centella asiatica is an important medicinal herb used in Ayurveda for skin diseases and wound healing. The plant contains triterpenoids such as asiaticoside, madecassoside, asiatic acid, and madecassic acid. Research studies indicated that asiaticoside stimulates collagen synthesis and angiogenesis.

Centella extract has been found to improve wound contraction and increase tensile strength.

Studies conducted on incision and excision wound models demonstrated:

- Faster epithelialization
- Increased hydroxyproline content
- Enhanced fibroblast proliferation
- Better collagen maturation

Centella asiatica is also known to stimulate type-I collagen synthesis and improve scar formation. Due to its regenerative properties, it is widely used in cosmetic and dermatological formulations.

5. *Ocimum sanctum* (Tulsi)



Ocimum sanctum is regarded as a sacred medicinal plant in India. Tulsi possesses antimicrobial, antioxidant, and anti-inflammatory properties beneficial for wound management. Studies showed that ethanolic extract of tulsi leaves significantly reduced wound area and accelerated healing in rats. Increased granulation tissue weight and collagen content were observed.

The presence of eugenol, ursolic acid, rosmarinic acid, and flavonoids contributes to its pharmacological activities. Tulsi extract also showed inhibitory activity against bacterial strains commonly associated with wound infection. Researchers concluded that tulsi promotes wound healing through:

- Reduction of oxidative stress
- Stimulation of collagen synthesis
- Anti-inflammatory action
- Antimicrobial activity

6. *Jatropha curcas*



Jatropha curcas latex and leaf extracts are traditionally used for treating cuts and wounds. Experimental studies reported that ointments prepared from *Jatropha* leaf extract significantly increased wound contraction and epithelialization rate. Histopathological analysis showed improved fibroblast proliferation and collagen organization.

The wound healing activity is mainly due to:

- Flavonoids
- Tannins
- Saponins
- Phenolic compounds

The antimicrobial activity of *Jatropha* extract further supports wound repair by preventing infection.

7. *Moringa oleifera*



Moringa oleifera has gained considerable scientific attention due to its nutritional and medicinal properties. Research investigations revealed that methanolic leaf extract of moringa significantly improved wound contraction and collagen deposition. Increased antioxidant enzyme activity was also reported.

The plant contains:

- Vitamin C
- Flavonoids



- Tannins
- Phenolic compounds
- Beta-carotene

These constituents help neutralize free radicals and promote tissue repair. Moringa also exhibits antimicrobial activity against several pathogenic microorganisms.

8. Carica papaya



Carica papaya leaf and fruit extracts have been extensively studied for wound healing activity. Papaya contains papain enzyme, chymopapain, flavonoids, and vitamins which aid in wound debridement and tissue repair. Researchers observed accelerated wound contraction and increased granulation tissue formation following topical application of papaya extract. Papaya preparations are especially useful in infected and necrotic wounds due to their proteolytic and antimicrobial actions.

Studies indicated:

- Faster removal of dead tissue
- Enhanced collagen synthesis
- Reduced bacterial contamination
- Improved epithelialization

9. Terminalia arjuna



Terminalia arjuna bark extract has been traditionally used in Ayurvedic medicine for ulcers and wounds. Pharmacological studies demonstrated significant wound healing activity in experimental animal models. Increased wound contraction, hydroxyproline content, and tensile strength were reported.

The plant contains:

- Triterpenoids
- Tannins
- Flavonoids
- Glycosides

These phytoconstituents contribute to antioxidant and anti-inflammatory effects that support tissue repair.



10. *Pongamia pinnata*



Pongamia pinnata possesses antibacterial and anti-inflammatory properties useful in skin disorders and wound management. Studies showed that ethanolic extract of *Pongamia* leaves accelerated wound healing by increasing collagen synthesis and fibroblast activity. Reduction in wound size and healing period was observed in excision wound models. Karanjin and ongamol are major active constituents responsible for pharmacological activity. Mechanism of Herbal Wound Healing Medicinal plants promote wound healing through multiple mechanisms including:

1. Antimicrobial Activity

Many herbal extracts inhibit growth of bacteria and fungi present at wound sites, thereby

VII. MATERIALS AND METHODS

Materials

Plant Materials

The medicinal plants selected for the study were:

- Aloe vera leaves
- Curcuma longa rhizomes
- Azadirachta indica leaves

Chemicals Used

- Ethanol
- Methanol
- Distilled water
- Carbopol
- Petroleum jelly
- Glycerin
- Triethanolamine Instruments Used
- Soxhlet apparatus
- Rotary evaporator
- pH meter
- Electronic balance
- Hot air oven
- UV Spectrophotometer • Brookfield viscometer Experimental Animals

VIII. DISCUSSION

The present study demonstrated significant wound healing activity of selected Indian herbal extracts. The prepared herbal formulation exhibited good physicochemical properties and satisfactory stability suitable for topical administration. Phytochemical screening revealed the presence of flavonoids, tannins, alkaloids, terpenoids, glycosides, and phenolic compounds. These phytoconstituents are known to possess antimicrobial, antioxidant, anti-inflammatory, and collagen promoting properties which contribute significantly to wound healing.



The excision wound model showed faster wound contraction and reduced epithelialization period in treated animals. This may be due to enhanced fibroblast proliferation, collagen synthesis, and angiogenesis produced by herbal extracts. In the incision wound model, increased tensile strength indicated improved collagen maturation and tissue remodeling. Better collagen deposition strengthens repaired tissue and accelerates wound closure. The antimicrobial activity of the extracts helped prevent microbial contamination at wound site. Reduction of infection is important for rapid wound healing and prevention of complications. The antioxidant activity of the herbal extracts protected tissues from oxidative stress caused by free radicals generated during injury. Antioxidants reduce cellular damage and promote tissue regeneration.

Histopathological studies confirmed enhanced collagen formation, fibroblast proliferation, angiogenesis, and epithelialization in treated groups. Reduced inflammatory cell infiltration indicated anti-inflammatory activity of the herbal extracts. Among the selected plants, Aloe vera, Curcuma longa, and Azadirachta indica showed excellent wound healing properties due to synergistic pharmacological activities. Overall, the results scientifically validate the traditional use of Indian medicinal plants in wound management. The study suggests that herbal formulations may serve as safe, effective, economical, and promising alternatives to synthetic wound healing agents.

IX. CONCLUSION

The present study demonstrated that selected Indian herbal extracts possess significant wound healing activity due to their antimicrobial, antioxidant, and anti-inflammatory properties. The prepared herbal formulation showed faster wound contraction, improved collagen synthesis, enhanced epithelialization, and better tissue regeneration in experimental wound models. Phytochemical constituents such as flavonoids, tannins, alkaloids, and phenolic compounds were found responsible for the therapeutic activity. The study scientifically validates the traditional use of medicinal plants like Aloe vera, Curcuma longa, and Azadirachta indica in wound management.

Thus, herbal formulations may serve as safe, effective, economical, and promising alternatives to synthetic wound healing agents.

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