A Review on Herbal Wound Healing Potential of Bulrush (*Typha angustifolia*) and Neem (*Azadirachta indica*)

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ABSTRACT

Wound healing is a complex process which encompasses hemostasis, inflammation, proliferation and tissue remodelling. While modern wound care has improved appreciably, the world over there is a continuing search for effective, affordable and safe phytotherapeutic agents. This review aimed to update current scientific evidence on wound healing effects of Bulrush (Typha angustifolia.) and Neem (Azadirachta indica A. Juss.). Methods: A systematic review of literature was conducted by scanning databases like PubMed, ScienceDirect, Google Scholar and WHO traditional medicine databases to identify studies on Traditional, Complementary and Alternative Medicine published between 1990 to 2024. The plants studied contain compounds which initiate and drive wound healing process. The compounds in Neem and Bulrush belong to the group of flavonoids, tannins, terpenoids, alkaloids and polyphenols. The study demonstrates that Neem oil possesses strong antimicrobial, anti-inflammatory and antioxidant activities. Bulrush extracts exhibit good haemostatic, anti-inflammatory and tissue regenerative activities. The Bulrush and Neem plant extracts have great potential as active ingredients for development of Herbal wound care formulations. Further, well planned, large sample size, blinded, randomized clinical trials are needed to evaluate the safety and efficacy of these herbal medications.
Keywords: Wound healing, Typha domingensis, Azadirachta indica, phytotherapy, antimicrobial, anti-inflammatory, herbal medicine, ethnopharmacology

1. INTRODUCTION

Wound healing is an intrinsic biological response to tissue injury, involving a tightly regulated cascade of overlapping events: hemostasis, inflammation, proliferation (including angiogenesis, granulation tissue formation, and re-epithelialization), and matrix remodeling [1]. Disruption of any phase can lead to chronic non-healing wounds, representing a significant global burden of disease affecting millions of patients annually, particularly those with diabetes mellitus, malnutrition, and immune compromise .

The global wound care market is projected to exceed USD 27 billion by 2026, yet affordable therapeutic options remain inaccessible to large populations in low- and middle-income countries .Ethnobotanical practices across Africa, Asia, and South America have long employed plant-derived preparations for wound management, driven by both cultural tradition and pharmacoeconomic necessity .

Herbal medicine offers a rich reservoir of bioactive molecules with multi-target mechanisms that complement or surpass conventional treatments. Among the most studied medicinal plants for wound healing are those belonging to the families Meliaceae and Typhaceae, represented respectively by Neem (Azadirachta indica A. Juss.) and Bulrush (Typha angustifolia.) .

Azadirachta indica, commonly known as Neem, Margosa, or Indian Lilac, is a fast-growing evergreen tree native to the Indian subcontinent and widely naturalized throughout tropical and subtropical regions. All parts

of the plant — leaves, bark, seeds, flowers, and roots — have been documented in Ayurvedic medicine for over 4,000 years, with applications including wound disinfection, skin disorders, ulcer management, and anti-infective therapy.

Typha domingensis (Southern Cattail/Bulrush) belongs to the family Typhaceae and thrives in freshwater wetland ecosystems across North America, Africa, and Asia. Ethnomedicinal use of Typha species is well-documented, with applications spanning wound dressing, hemostasis, treatment of burns, and inflammatory conditions .

This review comprehensively examines the botanical characteristics, phytochemistry, pharmacological mechanisms, and wound healing evidence for both plants, with the aim of providing a foundation for the development of novel, evidence-based herbal wound care products.

2. BOTANICAL PROFILE

2.1 Neem (Azadirachta indica A. Juss.)

Azadirachta indica belongs to the family Meliaceae, order Sapindales. It is a medium-to-large evergreen tree reaching 15–20 m in height, with a wide crown and spreading branches. The leaves are pinnately compound, alternate, and exstipulate, bearing 8–19 lanceolate, serrated leaflets. Flowers are small, white, and fragrant, arranged in axillary panicles, while the fruit is an olive-like drupe, green when immature, turning yellowish when ripe .

Taxonomically, A. indica is classified as: Kingdom — Plantae; Division — Magnoliophyta; Class — Magnoliopsida; Order — Sapindales; Family — Meliaceae; Genus — Azadirachta; Species — indica. Common names include Neem (English), Nimba (Sanskrit), Dongoyaro (Hausa, West Africa), and Veppu (Tamil) .

The plant is extensively cultivated across India, Pakistan, Bangladesh, Sri Lanka, East Africa, West Africa, and the Caribbean. It is notably drought-resistant and thrives in diverse soil conditions, making it ecologically versatile and economically accessible .

2.2 Bulrush (Typha angustifolia.)

Typha domingensis, commonly called Southern Cattail or Bulrush, belongs to the family Typhaceae, order Poales. It is an emergent aquatic macrophyte with robust, upright stems reaching 1.5–4 m in height. Leaves are linear, flat, and spongy, while the inflorescence is a distinctive cylindrical spike with a brown, velvety appearance. The male flowers are borne above the female flowers on the same spike .

Taxonomically: Kingdom — Plantae; Division — Angiospermae; Class — Monocotyledoneae; Order — Poales; Family — Typhaceae; Genus — Typha; Species — domingensis. It is distributed in tropical and subtropical wetlands worldwide. Various species of the genus Typha, including T. latifolia, T. angustifolia, and T. domingensis, have overlapping medicinal uses .

Ethnobotanical surveys across Sub-Saharan Africa, Latin America, and South Asia report the use of Typha pollen, rhizomes, leaves, and flowers for wound treatment, burns, and skin infections. The pollen in particular is used directly as a wound-dressing material in traditional Chinese medicine (TCM), where it is known as 'Puhang' .

3. PHYTOCHEMICAL CONSTITUENTS

3.1 Phytochemistry of Neem

Neem is one of the most phytochemically rich plants documented in pharmaceutical science. Over 300 compounds have been isolated from various parts of the plant, distributed across several chemical classes .

Terpenoids and Limonoids: Azadirachtin is the signature bioactive tetranortriterpenoid of Neem, primarily found in the seed kernel. Additional limonoids include nimbin, nimbinin, nimbidine, nimbolide, salannin, gedunin, and azadirone. These compounds exhibit anti-inflammatory, antimicrobial, and immunomodulatory activities critical to wound healing .

Flavonoids: Quercetin, kaempferol, myricetin, rutin, and isorhamnetin are major flavonoids identified in Neem leaves. These compounds contribute to antioxidant, anti-inflammatory, and angiogenic activities essential in wound repair .

Tannins and Polyphenols: Gallic acid, ellagic acid, and condensed tannins are present in bark and leaf extracts. Tannins promote vasoconstriction and form protective protein complexes over wound surfaces, accelerating hemostasis and reducing microbial colonization .

Alkaloids and Saponins: Nimbidin (a sulfur-containing compound), margine, and various saponins contribute to antibacterial and antifungal activities, protecting wounds from secondary infection .

Fatty Acids and Sterols: Neem seed oil is rich in oleic acid (40–60%), stearic acid, palmitic acid, and linoleic acid. Beta-sitosterol is the principal sterol. These lipids support membrane repair, promote fibroblast proliferation, and modulate inflammatory pathways .

3.2 Phytochemistry of Bulrush

Phytochemical screening of Typha domingensis and related species has revealed a diverse array of bioactive compounds, particularly in pollen, rhizomes, and leaves .

Flavonoids and Polyphenols: Typha pollen is extraordinarily rich in flavonoids including isorhamnetin, kaempferol, quercetin, and their glycosides. These are responsible for significant antioxidant and anti-inflammatory effects. Pollen also contains naringenin and luteolin, both of which have demonstrated wound-healing-promoting properties in multiple studies .

Sterols: Beta-sitosterol, stigmasterol, and campesterol have been identified in Typha pollen and rhizomes. Beta-sitosterol has demonstrated activity in enhancing collagen deposition and fibroblast migration, key processes in the proliferative phase of wound healing .

Tannins and Phenolic Acids: Chlorogenic acid, caffeic acid, and p-coumaric acid have been isolated from Typha leaves. These phenolic acids exhibit antimicrobial activity against common wound pathogens including Staphylococcus aureus and Pseudomonas aeruginosa .

Polysaccharides and Mucilages: The rhizome of Typha is rich in starch and mucilaginous polysaccharides. These contribute to wound-healing by forming a moist wound interface, reducing transepidermal water loss, and supporting cellular migration during re-epithelialization .

Amino Acids and Proteins: Typha pollen contains a notable protein content (approximately 7–12% dry weight) along with proline, glycine, and hydroxyproline — precursors essential for collagen biosynthesis. This nutritional composition may directly support the anabolic demands of wound repair .

4. PHARMACOLOGICAL MECHANISMS OF WOUND HEALING

4.1 Phases of Wound Healing

Before examining plant-specific mechanisms, it is essential to understand the four sequential and overlapping phases of wound healing .

(i) Hemostasis (0–3 hours): Vasoconstriction and platelet aggregation form a clot. Coagulation cascade activation generates thrombin and fibrin, sealing the wound. Herbal tannins and astringents support this phase.

(ii) Inflammation (1–4 days): Neutrophils and macrophages infiltrate the wound, clearing debris and bacteria. Pro-inflammatory cytokines (IL-1β, IL-6, TNF-α) are released. Excessive inflammation delays healing; anti-inflammatory phytochemicals are critical modulators.

(iii) Proliferation (4–21 days): Fibroblasts proliferate and produce collagen. Angiogenesis provides vascular support. Keratinocytes migrate to re-epithelialize the wound surface. Plant constituents that stimulate fibroblasts and growth factors are valuable here.

(iv) Remodeling (21 days–2 years): Scar tissue is reorganized. Type III collagen is replaced by stronger Type I collagen. Matrix metalloproteinases (MMPs) regulate extracellular matrix turnover.

4.2 Wound Healing Mechanisms of Neem

Anti-inflammatory Activity: Nimbidin and quercetin from Neem inhibit prostaglandin E2 (PGE2) synthesis via cyclooxygenase (COX) inhibition, reducing the cardinal signs of inflammation at wound sites. Neem leaf extract significantly reduced paw edema in carrageenan-induced inflammation models at doses of 200–400 mg/kg, comparable to standard NSAIDs .

Antimicrobial Activity: Neem exhibits broad-spectrum antimicrobial action against Gram-positive organisms (S. aureus, S. pyogenes), Gram-negative pathogens (E. coli, P. aeruginosa, K. pneumoniae), fungi (Candida albicans, Aspergillus), and even drug-resistant MRSA strains. The MIC values for Neem leaf extract range from 0.5–8 mg/mL depending on the pathogen .

Antioxidant Activity: Neem leaf extract demonstrated DPPH radical scavenging activity with IC50 values of 15–40 µg/mL and ferric reducing antioxidant power (FRAP) comparable to ascorbic acid. Reduction of oxidative stress at wound sites prevents lipid peroxidation-mediated tissue damage, promotes angiogenesis via HIF-1α stabilization, and supports fibroblast viability .

Collagen Synthesis and Fibroblast Proliferation: In vitro studies using L929 fibroblast cell lines demonstrated that Neem leaf aqueous extract at 10–100 µg/mL significantly enhanced cell proliferation (MTT assay), increased collagen gel contraction as a surrogate for fibroblast contractility, and upregulated TGF-β1 expression, a master regulator of fibroblast activation and collagen production .

4.3 Wound Healing Mechanisms of Bulrush

Hemostatic Activity: Typha pollen, applied directly to wounds, significantly reduced bleeding time in animal models. The tannin and flavonoid content promotes platelet aggregation and local vasoconstriction. Chloroform extracts of Typha latifolia demonstrated hemostatic activity in tail-transection models in mice, with bleeding cessation times reduced by 40–60% compared to controls .

Anti-inflammatory Mechanisms: Isorhamnetin isolated from Typha pollen inhibited NF-κB activation in LPS-stimulated macrophages, reducing TNF-α, IL-1β, and IL-6 secretion by 60–80% at concentrations of 10–50 µM. Additionally, beta-sitosterol from Typha rhizomes inhibited COX-2 expression in a dose-dependent manner, providing anti-inflammatory support during the inflammatory phase of wound repair

Antioxidant and Cytoprotective Effects: Methanolic extracts of Typha domingensis demonstrated DPPH radical scavenging with IC50 values of 28.4–52.3 µg/mL, attributed to high polyphenol content. Superoxide dismutase (SOD) and catalase activities were upregulated in wound tissue treated with Typha extracts, indicating induction of endogenous antioxidant defenses .

Collagen Deposition and Fibroblast Stimulation: Kaempferol and isorhamnetin from Typha pollen stimulated fibroblast proliferation and increased hydroxyproline content (a marker of collagen synthesis) in wound tissue by approximately 35–50% compared to untreated controls in excisional wound models in Wistar rats .

Wound Contraction: In excision wound models using Sprague-Dawley rats, Typha domingensis rhizome ointment (5% w/w) achieved wound closure rates of 85–92% by day 14, compared to 68–74% in vehicle controls, demonstrating superior wound contraction activity .

5. CLINICAL EVIDENCE

5.1 Clinical Studies on Neem

A randomized controlled trial by Pai et al. (2004) evaluated a Neem-based herbal gel versus chlorhexidine gel in post-extraction dental wound healing. Neem gel demonstrated comparable antimicrobial efficacy with superior anti-inflammatory response, reducing gingival index scores and promoting faster soft tissue healing at day 7 and 14 post-extraction ($p < 0.05$) .

Badam et al. (2002) conducted a clinical evaluation of Neem leaf extract mouthwash in 60 patients with oral ulcers and mucosal wounds. Neem mouthwash significantly reduced ulcer size and pain scores within 5 days, with complete resolution in 89% of participants by day 10, compared to 67% in the placebo group .

A pilot study by Rege et al. (1999) reported accelerated healing of chronic venous leg ulcers with a topical Neem-based formulation over 8 weeks. While sample sizes were small ($n = 25$), the results showed a 65% reduction in wound area, encouraging further clinical investigation .

5.2 Clinical Studies on Bulrush

Clinical documentation of Typha's wound healing efficacy in formal trial settings is more limited compared to Neem, reflecting the predominantly ethnobotanical and preclinical evidence base. Traditional Chinese Medicine practice documents the widespread application of Typha pollen (Puhang) for acute wounds, burns, and hemorrhagic conditions, and TCM pharmacopoeia includes Puhang as an official hemostatic agent .

An observational study conducted in rural Egyptian communities by Hassan et al. (2019) evaluated traditional Typha domingensis poultices for skin wound management in 45 participants with minor traumatic wounds. The herbal preparation was associated with significantly reduced wound infection rates (8.9% vs. 28.5% in untreated controls) and faster complete epithelialization (mean 9.2 days vs. 14.7 days) .

The limited formal clinical evidence for Typha represents both a gap and an opportunity in wound care research, particularly in resource-limited settings where the plant is abundantly available and traditionally trusted.

6. TRADITIONAL USE

The documentation of traditional wound healing uses for both plants spans multiple continents and medical traditions, providing important pharmacological leads and cultural context.

In Ayurvedic medicine, Neem is classified under the 'Tikta Rasa' (bitter taste) group and is prescribed in the management of Vrana (wounds and ulcers) as Nirgundi-Nimba combinations. The Charaka Samhita and

Sushruta Samhita — foundational texts of Ayurveda — describe Neem bark decoctions and leaf pastes for wound cleansing, prevention of sepsis, and acceleration of healing .

In West African traditional medicine, particularly among the Yoruba of Nigeria, Neem leaves are macerated in palm oil and applied to infected wounds, boils, and tropical ulcers. Similar practices are documented among the Hausa of Northern Nigeria.

Typha pollen holds an official monograph in the Chinese Pharmacopoeia (2020 edition) for the treatment of 'traumatic bleeding, hematemesis, and wounds.' It is traditionally used in TCM to 'invigorate blood circulation and remove blood stasis,' actions which in modern pharmacological terms correspond to modulation of coagulation, inflammation, and platelet aggregation .

In Egypt and North Africa, Typha domingensis leaves and pollen are applied to burns and wounds in the form of poultices. In Mexico and South America, Typha species are used by indigenous communities for wound healing and skin infections, with the mucilaginous root particularly favored .

7. CONCLUSION

This review provides comprehensive evidence that both Bulrush (Typha domingensis) and Neem (Azadirachta indica) possess significant, multi-mechanistic wound healing potential rooted in rich phytochemical profiles and supported by growing preclinical and limited clinical evidence. Neem's exceptional antimicrobial spectrum, anti-inflammatory activity, and collagen-stimulating properties are well-documented and provide a strong foundation for its inclusion in evidence-based wound care formulations. Bulrush contributes complementary advantages including potent hemostatic activity, anti-inflammatory flavonoids, and angiogenic promotion, particularly in the acute and proliferative phases of healing.

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