

**Green Miracles: Unravelling the Efficacy of Phytoconstituents in Wound Healing:
A Comprehensive Review**

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ABSTRACT

A wound is an inevitable condition that may develop anytime during a person's lifespan and can be caused by physical trauma that causes a rupture or tear in the skin. Wounds can have a substantial impact on millions of patient's physical and mental well-being, placing a heavy financial load on them. Since ancient times, many ailments and wounds have been successfully treated using medicinal herbs. Many pharmaceutical preparations are currently in the market to treat wound injuries; however, they all have some limitation or the other. Moreover there is a dire need to explore remedies for chronic wounds as in case of diabetic patients. Besides wound infections with antibiotic-resistant bacteria can lead to prolonged debility in patients, delaying the healing process and increasing healthcare costs. Phytoconstituents, found in plants, often possess therapeutic properties that can aid in effective wound healing and management. Certain contemporary dressings absorb fluid quickly, lose their rheological properties, and become flexible, which reduces their ability to stay on the wound site. This review lists numerous medicinal plants and their active ingredients that have been shown through study to have wound-healing properties. Medicinal plants have a wide variety of Phytoconstituents like alkaloids, glycosides, terpenoids, triterpenes, and flavonoids, as their primary active components that are effective in not only wound healing but treating a wide range of illnesses..

Keywords: Wound healing, Medicinal plants, Phytoconstituents, Chronic Wounds, Infections, antibiotic –resistant bacteria.

INTRODUCTION

Medicinal plants are typically defined as those plants extensively used in treating and preventing specific ailments. These plants could be either naturally occurring wild species or domesticated ones that have been cultivated by humans^[1]. Medicinal plants have substantially improved global health. Despite the fact that modern medicine has made enormous strides. Plants remain as important medicine even in the most recent decades and have been explored extensively for their therapeutic applications^[2].

Wound care practitioners have returned to the age - old healing techniques by utilizing traditional and alternative medicine in wound management due to

the rise of multi-resistant organisms and decline in the use of newer antibiotics. There has been a positive shift in people's perceptions on traditional medicine^[3]. In many nations, a wide variety of plant extracts, mixtures, pastes are equally utilized to cure illness, burns, cuts and wounds^[4]. Numerous phytoconstituents, including polyphenols, alkaloids, and triterpenes, have antibacterial and antioxidant properties and can support one or more pathway of the healing process^[5]. The most common mechanisms behind phytochemical-mediated enhanced wound healing include their antioxidant, anti-inflammatory, and anti-microbial properties, which collectively support the healing process^[6]. Phytoconstituents with astringent and antibacterial qualities, such as

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triterpenoids and flavonoids, play a role in controlling infections, supporting an environment conducive to healing.^[7]

Wound Healing Process

Wound healing is a complex, dynamic process that involves a series of coordinated events aimed at restoring the integrity and functionality of damaged tissue. The process can be broadly categorized into three main phases:

1- Inflammatory Phase-^[8]

Initiation - Begins immediately after injury with blood vessel constriction to minimize bleeding.

Vasodilation and permeability- Blood vessels widen, allowing immune cells and nutrients to reach the wound site.

Phagocytosis- White blood cells remove debris and bacteria, promoting a clean environment for healing.

Cytokine release- Signalling molecules regulate the immune response and attract cells involved in tissue repair.

2- Proliferative Phase-^[9]

Granulation tissue formation-Fibroblasts produce a matrix of collagen and other proteins, forming granulation tissue.

Angiogenesis- New blood vessels develop to supply nutrients and oxygen to the growing tissue.

Epithelialization- Epithelial cells migrate over the wound surface to cover it.

Contraction - The wound edges contract, reducing the wound area.

3- Maturation or Remodelling Phase – ^[10]

Collagen reorganization -Collagen fibers undergo rearrangement to increase tissue strength.

Scar formation-Excess collagen is remodelled, leading to scar tissue.

Classification of Wounds

According to the underlying reason of the wound's genesis, Wounds can be categorized as acute or

chronic based on the physiology of wound healing, as well as open or closed.

Open wounds

In this instance, bleeding is obviously evident as blood leaves the body. It is further categorized as: severed wound, Tear wound or laceration, scratches or cuts that are shallow, wounds from punctures, Gunshot wounds and penetration wounds ^[11].

Closed wounds

When wounds are closed, blood still stays inside the body but leaves the circulatory system. Hematomas or blood tumors, crush injuries, contusions or bruises, etc. are included under this category

Acute wounds

An acute wound is a type of tissue injury that typically arises from a quick, orderly healing process that preserves the wounded area's functional and anatomical integrity. Acute wounds are typically the result of cuts or surgical incisions, and they recover within the expected period of time range ^[12].

Chronic wounds

Wounds that have advanced from their first stages of healing into a state of pathologic inflammation are referred to as chronic wounds. These wounds either never completely heal or keep recurring. Acute infection, lack of oxygen, foreign materials, trauma and general health issues including Type 2 diabetes, malnourishment, immune deficiency, or medication interactions are the most frequent causes of chronic wounds. ^[13-14]

Essential Phytoconstituents and Their Role in Wound Healing

Phytoconstituents	Chief Action In Wound Healing
Tannins and flavonoids	Enhancement of tensile strength, acceleration of wound contraction, and homeostasis ^[15]
Vitamins	Encourage tissue healing and retain the integrity of the

minerals	wound ^[16]
Glycosides	Stimulating wound closure, lowering inflammation near the site, and acting as an anti-inflammatory ^[17]
B- carotene	Strengthening wounds, promoting collagen formation, and antioxidant ^[18-19]
Saponins	Increase blood clotting, assisting in the first phase of wound healing ^[20]
Polyphenols	Increase keratinocyte and fibroblast activity, have an anti-inflammatory impact ^[21-23]
Steroids	Constriction of the wound, fibroblast migration and proliferation ^[25]
Anthocyanin	Reducing inflammation and oxidative stress during the healing of wounds, anti-oxidant ^[24]

Saponins another class of phytoconstituents in marigold, may contribute to its antimicrobial properties, preventing infections at the wound site and supporting overall wound healing.^[29] In wound healing, the flowers of *Calendula officinalis* are predominantly used. The petals of *Calendula* flowers contain various bioactive substances, comprising flavonoids, saponins, and triterpenoids, which contribute to their healing properties^[30].

Several studies conducted utilizing cultures of both human and mouse fibroblasts have reliably indicated that extracts of *Calendula officinalis* induce fibroblast migration, showcasing the potential wound-healing properties of *Calendula officinalis*. These studies observed enhanced proliferation and migration of fibroblasts when exposed to *Calendula officinalis* extracts, indicating a positive impact on wound healing processes. The extracts, even at low concentrations, were found to promote cell numbers and migration of fibroblasts, crucial components in the wound healing cascade. Additionally, the extracts were associated with increased levels of key factors such as TGFβ1 and bFGF, further supporting their role in wound healing.^[31]

Some Medicinal Plants With Significant Wound Healing Properties

Calendula officinalis

Calendula officinalis or pot marigold, has a history in wound healing dating back centuries. Historically, *Calendula* has been used as a vulnerary herb, approved by ESCOP and the German Commission E for treating minor inflammations of the skin.^[26]

Flavonoids, which have anti-inflammatory and antioxidant qualities, are abundant in *calendula officinalis*. These substances are vital for creating an environment that is conducive to healing by lowering inflammation and oxidative stress at the site of the wound.^[27]

The presence of triterpenoids in *Calendula officinalis* contributes to its wound healing potential. Triterpenoids are believed to enhance the formation of connective tissue and promote tissue repair.^[28]

Curcuma longa

Curcuma longa, commonly known as turmeric, has a rich history in wound healing and traditional medicine.^[32] The main active compound in turmeric, curcumin has powerful antioxidant and anti-inflammatory properties, promoting wound healing by lowering oxidative stress and inflammation.^[33] Besides curcumin, turmeric contains other curcuminoids like demethoxycurcumin and bisdemethoxycurcumin, contributing to its overall therapeutic effects on wounds.

In a rat model study, high-dosage curcumin therapy for 15 days was linked to decreased ciliary degeneration and loss, as well as reduced cellular proliferation relative to control categories. The study suggests that curcumin contributes to the reduction of inflammatory responses, accelerating the wound healing process.^[34] Additionally, a combination of substance P (SP) and curcumin has been shown to enhance wound healing in diabetic

rats, demonstrating a synergistic effect. Topical treatment with curcumin has also been observed to promote re-epithelialization in burn wounds, leading to a shorter wound healing time.^[35] The application of Curcumin Nanoparticles-Hydrogel in diabetic rat skin wounds resulted in faster recovery, increased wound closure rate, and improved granulation tissue formation.^[36] Rhizome, or underground stem, of *Curcuma longa*, is primarily used for its medicinal benefits. It is from the rhizome that turmeric powder, oil, or extracts are derived for various applications, including wound healing.^[37-38]

Acacia Catechu

Acacia catechu, commonly known as catechu or khair, contains various phytoconstituents that contribute to its medicinal properties. The traditional use of *Acacia catechu* in wound healing is rooted in its pharmacological properties, such as antimicrobial, antifungal, and antibacterial actions. Historically, *Acacia catechu* has been employed in traditional medicine to address wounds, skin irritations, and other dermatological issues.^[39]

Acacia catechu is rich in catechins, which are a type of flavonoid with antioxidant properties. Flavonoids are a comprehensive set of plant chemicals recognized for their anti-inflammatory and antioxidant effects. Tannins, particularly condensed tannins, are present in *Acacia catechu*. These compounds have been associated with various biological activities, including antimicrobial and anti-inflammatory effects.^[40] The bark of *Acacia catechu* is primarily used for wound healing purposes. The bark extract has been shown to possess bioactive compounds such as catechins, flavonoids, tannins, alkaloids, and phenolic compounds that contribute to its medicinal properties, including wound healing capabilities.^[41] *Acacia catechu* has demonstrated significant wound healing potential in rats. Studies, such as the one testing the ability of alcoholic and aqueous extracts of *Acacia catechu* bark to treat wounds in rats as an ointment has shown encouraging findings. The extracts, applied in different concentrations, exhibited positive effects on wound healing, indicating the plant's efficacy in promoting tissue repair in wound healing.^[42]

Ginkgo Biloba

Ginkgo biloba, sometimes referred to as maidenhair tree or ginkgo, is a deciduous dioecious Chinese tree recognized for its fan-shaped leaves and fleshy yellow seeds. The gymnosperm tree *ginkgo biloba* is indigenous to East Asia and is regarded as a living fossil since its fossils date back 270 million years. *Ginkgo biloba* is rich in flavonoids and their glycosides. These compounds exhibit antioxidant properties, which are crucial for neutralizing free radicals, supporting tissue repair, and promoting an environment conducive to wound healing.^[43] *Ginkgo biloba* contains terpenoids, contributing to its pharmacological activities. Terpenoids may play a role in anti-inflammatory processes, helping to reduce inflammation at the wound site.^[44]

The plant part of *Ginkgo biloba* used in wound healing is primarily the leaf extract. Studies and formulations, such as creams and gels, often utilize *Ginkgo biloba* leaf extract for its potential wound healing properties. The leaf extract contains bioactive compounds, including flavonoids and terpene trilactones, which contribute to its pharmacological activities.^[45] Animal models have demonstrated an increased rate of wound closure with *Ginkgo biloba*, attributed to its potential to enhance collagen production.^[46] Additionally, experimental studies in rats have shown that *Ginkgo biloba* accelerates bone formation and improves fracture healing. The development and evaluation of topical treatments, such as creams and nanocomplex gels containing *Ginkgo biloba* extract, have further highlighted its efficacy in wound management.

Panax Ginseng

Panax ginseng, commonly consumed in China, Japan, Korea, and Eastern Siberia, is renowned for its various health benefits. It is a well-liked medical herb that improves memory, focus, and thinking. *Panax ginseng* is a multipurpose plant with a broad variety of possible uses as it is said to enhance immunity, increase physical stamina, and lessen weariness.^[47] *Panax Ginseng* is rich in bioactive compounds, particularly saponins, known as ginsenosides, which contribute to its

wound-healing properties. Total Ginseng Saponin [TGS] has been identified as a key component with therapeutic effects on skin wounds, demonstrating a beneficial impact on the cutaneous wound healing process, as indicated by histological analysis in studies^[48-49]. Panax ginseng root extracts exhibit protective effects against UVB irradiation in C57BL mice, preventing skin damage such as increases in skin thickness and pigmentation. Furthermore, these extracts greatly accelerate the healing process following excisional injuries and laser injuries from burns. Research shows that in vitro, Panax ginseng extracts increase collagen production, induce proliferation, and facilitate keratinocyte migration in human dermal fibroblasts.^[50] The root extracts of Panax ginseng have been studied for their wound-healing properties, showing positive effects in processes like skin regeneration and collagen synthesis^[51]

Ampelopsis Japonica

The roots of the plant *Ampelopsis japonica*, which is indigenous to eastern Asian countries and eastern N. America, have long been used in traditional medicine. One notable application includes the treatment of burns and ulcers. *Ampelopsis japonica* has a history of being employed as a remedy for burns and ulcers in traditional medicine^[52]. Catechin, Gallic acid, Resveratrol, and Epicatechin. These are the primary antioxidant elements found in the root of *Ampelopsis japonica*, contributing to its therapeutic effects, including wound healing

Ethanol extracts from the desiccated roots of *Ampelopsis japonica* (JE) have been shown in research by Lee et al. to influence the healing of scald injuries on the skin in rats. AJE therapy sped up the healing process and had a noticeable impact on cytokine expression. Transforming growth factor- beta 1 and tumor necrosis factor-alpha-- 1 levels were observed to be elevated 2 days after injury, reflecting an early inflammatory response. However, these levels declined as the healing process advanced. On the other hand, interleukin-10 (IL-10) levels were discovered to be increase after 14 days, matching with the wound closure. This suggests a shift towards an anti-inflammatory

response during the later stages of wound healing.^[53]

Rosmarinus Officinalis

The phytoconstituents found in *Rosmarinus officinalis*, or common rosemary, aid in the plant's ability to heal wounds. borneol (1.5–5.0%), 1-8 cineole (15-55%) and camphor (5.0–21%)^[54] In a rat model with disseminated *Candida albicans* infection, Nejati et al.'s study shown that topical use of Rosemary officinalis essential oil promoted wound healing.^[55] The proliferative phase of wound healing in rats was utilized by Abu-Al-Basal to demonstrate the significant therapeutic impact of Rosemary officinalis essential oils^[56]. Researchers Hadizadeh-Talasaz et al. looked into the effects of rosemary cream on rat episiotomy wound healing, and their findings suggested some advantages.^[57] Labib et al. appraised the wound healing potential of Rosemary officinalis in vivo using an excision wound model in rats^[58]. Rosemary leaves are a common source for extracting essential oils and other phytochemicals with antioxidant and antimicrobial properties that aid in wound healing.^[59] In an in vivo study using BALB/c mice,. Abu-Al-Basal demonstrated that when it came to curing diabetic lesions, the essential oil of *Rosmarinus officinalis* outperformed the aqueous extract. Overall, the study was successful in treating diabetic wounds.^[60]

Aloe Vera

Aloe vera belongs to the Lilaceae family, sometimes referred to as *Aloe barbadensis*. The Arabic word "alloe," which meaning "bitter," is where the term "aloe" originates. Increasingly, aloe vera is utilized in the creation of novel food products because of its therapeutic and functional properties. Aloe vera contains a variety of naturally occurring bioactive compounds, including simple and complex water-soluble polysaccharides, pyrocatechol, saponins, acemannan, anthraquinones, glycosides, and oleic acid.^[61] Kaufman et al.'s 1988 study examined the use of gel for experimental second-degree burns in guinea pigs. Researchers investigated their effects on wound contraction, epithelialization, hair

follicle restoration, and newly created granulation tissue. After that, these results were compared to wounds that received treatment with 1% AgSD cream^[62] The benefits of aloe vera on wound healing were examined by Davis et al. ^[1989], both topically and orally. Wounds were created on each side of the ICR mice's spinal column using a biopsy punch. For two months, the oral research animals' drinking water included aloe vera, whereas the control group had only received water. Experimental animals received topically 25% Aloe vera in Eucerin cream for the topical investigation. The meal provided for the control group consisted just of cream.^[63]

avis et al. (1989) studied the influence of Aloe vera orally and topically on wound healing. Wounds were introduced on both sides of the vertebral column of ICR mice with a biopsy punch. In the oral study, experimental animals were given Aloe vera in their drinking water for 2 months, while the control animals received only water. For the topical study, experimental animals were received 25% Aloe vera in Eucerin cream topically.

The control group received cream only Aloe vera's effects on wound healing were investigated by Davis et al. (1989) both topically and orally. Using a biopsy punch, wounds were created on both sides of the ICR mice's spinal column. For two months, the animals used in the oral research were given aloe vera in their drinking water, while the control group merely got water. Experimental animals were given topically 25% Aloe vera in Eucerin cream for the topical investigation. The only food provided to the control group was cream.^[63]

Jojoba

The perennial woody shrub known as jojoba (*Simmondsia chinensis* C.K. Schneid) is indigenous to the semiarid areas of the southern state of Arizona, southern California, and northwest Mexico.^[64] Jojoba oil is a pale yellow, naturally occurring oil that can be applied topically to soothe wounds and repair skin barriers. Jojoba oil comprises 97% linear long-chain esters along with other bioactive compounds such as alkaloids, polyphenols, and flavonoids. Jojoba oil dry nanoemulsion powders (JND) have been shown to

be useful as free radical eliminators and natural-based anti-inflammatories for healing acute lung injury (ALI) by reducing bleeding and inflammatory cell infiltrations in ALI models.^[65] Additionally, a prior study demonstrated that jojoba liquid wax (JLW) fastly promotes the closure of wounds by both keratinocytes and fibroblasts. additionally, it was shown that JLW's effects on skin cells encourage fibroblasts to generate collagen I. The pharmacological characterization of JLW suggests that it might be employed to heal wounds in clinical settings.^[66]

Catharanthus Roseus

Catharanthus roseus L (apocyanaceae), is an endemic to the Caribbean region and has a history in medicinal remedy for a variety of illnesses. European herbalists employed the plant as an ancient remedy for diabetes and for a variety of other ailments, including headaches. It contains about 400 identified alkaloids, some of which have been approved for use as antineoplastic treatments for cancer, neurological tumors, Hodgkin's disorder, leukemia, and other diseases. Alzheimer's and vascular dementia have been demonstrated to be lessened by its vasodilating and memory-improving qualities.^[67-68] The most probably active chemical compounds found in *Catharanthus roseus* are designated as alkaloids. The plant comprises more than 400 alkaloids, which are utilized as insecticides, agrochemicals, flavors, fragrances, and elements in cuisine.^[69] Both wet flowers or dried and leaves are employed to create a paste applied to wounds in certain rural areas. When contrasted with the control group, rats given 100 mg/kg/day of the *Catharanthus roseus* ethanol extract showed a significant decrease in the epithelization time, an enormous rise in the hydroxyproline level and dry weight in the granulation tissue, and an elevated rate of wound contraction when compared to group under control. The use of *C. roseus* in the treatment of wound healing is supported by wound contraction, enhanced tensile strength, and hydroxyproline content.^[70]

Chamomile (*Matricaria Chamomilla*)

The species of renowned medical plant chamomile (*Matricaria chamomilla* L.), frequently referred to as the "star among medicinal species, is a member of the Asteraceae family.^[71] Research indicates that chamomile has antioxidant and anti-inflammatory qualities, which make it useful for treating a range of skin conditions, including wound healing.^[72] Topically applied chamomile flower extract has been demonstrated to improve collagen turnover, fibroblast count, re-epithelialization, and decrease wound size and inflammation. Moreover, studies on chamomile essential oil-loaded nanofibers for wound healing applications have demonstrated the plant's promise in cutting-edge wound care products.^[73] Many studies have examined the phytochemistry composition of *M. chamomilla* essential oils and extracts, and the results indicate that the plant has more than 120 compounds. Most essential oils are composed of terpenoids, which include α -bisabolol and its oxides A and B, β – Farnesene, and chamuzulene, amongst other compounds, comprise the majority of essential oils.

However, phenolic components, such as phenolic acids, flavonoids, and coumarins, predominated in *M. chamomilla* extract.^[74]

Tridax procumbens

Tridax procumbens, a blooming plant species in the family of daisy, is sometimes referred to as coat buttons or tridax daisy. It is most well recognized as a weed and pest plant. In India, *Tridax procumbens* has long been used as an insect repellent, anticoagulant, and wound healer. It has applications in diarrhea and dysentery.

In traditional medicine, its leaf extracts were used to cure infectious skin problems.^[75] Procumbenetin, a novel flavonoid derived from the aerial portions of *T. procumbens*, has been identified as 3,6-dimethoxy-5,7,2',3',4'-pentahydroxyflavone 7-O- β -D-glucopyranoside by chemical and spectroscopic methods.^[76]

Experimental studies indicate that the leaves of *Tridax procumbens* are used to make a juice has traditionally been used for healing skin wounds. The plant exhibits properties that influence the wound healing process, with both pro and anti-

inflammatory effects observed in experimental settings.^[77] Additionally, *Tridax procumbens* extracts have been associated with enhanced cell migration and wound healing, suggesting its potential application in promoting tissue repair.^[78]

Centella Asiatica

The herbaceous perpetual plant *Centella asiatica* is a member of the Apiaceae family., sometimes referred to as Umbelliferae, and is also referred to as Bua-bok, and Tiger grass, or Indian Pennywort. Because of its nutritional and medicinal qualities, it has a significant traditional significance, especially in South East Asia.^[79-80]

C. asiatica is utilized extensively because of its antibacterial, antioxidant, anti-inflammatory, neuroprotective, and wound-healing qualities.^[81-82] Seventy-five patients with second-degree burns were treated by Saeidinia et al. Once a day, either 1% silver sulfadiazine cream or Centriderm, a topical ointment containing CA, was applied topically to these individuals. The latter was included as a control in this investigation as it is typically employed as a regular therapy. The study group recovered more quickly than the group of control, requiring an average of 14.67 ± 1.78 days as opposed to the control group's 21.53 ± 1.65 days ($p = 0.001$). Additionally, the time it took for re-epithelialization was shorter in the CA group— 13.7 ± 1.48 days—than in the control group 20.67 ± 2.02 days¹ [$p < 0.0001$]. This result might be explained by *C. asiatica*'s influence on VEGF production, which is accelerated wound healing through the generation of IL-1 β by macrophages and monocyte chemoattractant protein-1 (MCP-1) by keratinocytes.^[83]

Urtica Dioica

Nettle, or stinging nettle, is the common name for *Urtica dioica* [*Urticaceae*]. This perennial herbaceous flowering plant thrives in temperate regions in Asia, America, North Africa, and Europe.^[84] According to reports, *Urtica dioica* possesses pharmacological properties that include antiviral, hypoglycemic, antibacterial, antioxidant, and anti-inflammatory properties.^[85-87] Rats' wound healing responses to a 5% and 2% ointment containing a 70% methanolic extract of a

combination of *U. dioica*'s leaves, roots, and aerials were examined at intervals of 7, 14, and 21 days. The ointments enhanced granulomatous tissue, angiogenesis, fibrogenesis, and epidermal thickness.^[88] In Wistar rats, the effects of a hydroethanol containing extract of *U. dioica* leaves on wound healing and haemostasis were examined. The excision wound closure rate was accelerated by the extract. It also raised the amount of hydroxyproline in the tissue. Epithelial regeneration, neovascularization fibroblasts, and a significant amount of inflammatory cells were seen upon histopathological inspection^[89] Using an excision wound model in Wistar rats, the saponin fraction extracted from Algerian *U. dioica* leaves was tested for its ability to promote wound healing. Rats treated with a 2:10 mixture of crude saponin and vaseline showed 100% wound contraction, which was greater than the results of the standard therapy^[90] The medicinal effects of *Urtica dioica* may be attributed to the abundance of bioactive substances found in its leaves, such as phenolic acids and flavonoids.^[91]

***Tephrosia Purpurea* Linn**

Tephrosia purpurea Linn., a member of the Leguminosae family *Sarwa Wranvishapaka* is another name for it. It has sterols, glycosides, rotenoids, isoflavones, flavonoids, chalcones, and flavonones. Many components of this plant are utilized as remedies for rheumatism, ulcers, gonorrhea, asthma, impotence, and urinary diseases in the Ayurvedic medical system. Additionally, it treats disorders of the liver, kidney, blood, heart, and spleen. The dried plant has laxative, soothing, and diuretic properties. It is also helpful to treat bronchitis, boils, bleeding piles, pimples, and leprous wounds. The roots and seeds are used as vermifuges and insecticidal agents. used for the skin eruption. Vomiting is treated with a decoction. An extract from the pods reduces pain and inflammation^[92] An ethanolic extract of *Tephrosia purpurea* (aerial component) in the form of a basic ointment was tested for its potential to cure wounds using three distinct types of wound models in rats: incision wound, excision injury and puncture wound. In terms of tensile power, contraction of the wound and histological

characteristics, and biological indicators including protein level and hydroxyproline content, the outcomes were similar to those of the standard medication

Fluticasone propionate ointment. In the histological investigation, the formation of blood vessels, collagen fibers, and fibroblast cells were all considerably ($P < 0.05$) enhanced. comparison to the control population, all parameters were shown to be significantly different ($P < 0.05$).^[93]

Citrus Tamurana

Japan's *Citrus Tamurana* (Rutaceae) is one of the citrus crops grown in Miyazaki. This particular crop has always been employed as a dietary supplement to improve appetite and digestion, reduce gas and distention in the abdomen, soothe respiratory issues, and help avoid coughing. It has been observed that *C. Tamurana* peel extract inhibits human CYP 3A cytochrome P450 3A and midazolam 1-hydroxylase activity.^[94-95] *Citrus reticulata*, a citrus fruit related to *Citrus Tamura*, produces fruit peels that provide an essential oil that has demonstrated wound healing and antioxidant properties^[96]. These results imply that *Citrus tamurana*'s advantageous effects on wound healing are partly attributed to the phytoconstituents contained in the fruit peel essential oil and leaf extract.

The impact of *C. tamurana* peel water extract on skin fibroblast (TIG-119) proliferation was investigated to see if *C. tamurana* promotes in vitro wound healing. At higher concentrations (>1 mg/mL), the extract inhibited TIG-119 cell proliferation; but, at lower concentrations (0.1, 0.25, 0.50, and 0.75 mg/mL), it demonstrated linear and time-dependent TIG119 cell growth. The extract accelerated the migration of cells toward the injured location in the scratch wound healing model. The G2 and M stages of the cell cycle were also enhanced by the extract (0.8 mg/mL). The extract boosted the expression of the genes encoding cyclin-dependent kinase 1 and 2 as well as Rac-1, Rho-A, and Cdc-42 m-RNA. But it didn't cause the protein to be produced.^[97]

Hibiscus Rosa- Sinensis

Hibiscus rosa-sinensis is a sterile shrub in the family Malvaceae. In the tropics, this plant is extensively grown as an ornamental. Numerous medical benefits of this plant have been shown, including anti-tumor, anti-oxidant, anti-hypertensive and anti-ammonia effects.^[98-99] The flower and leaves are useful for the growth of hair and healing of ulcers^[100-101] *Hibiscus rosa sinensis* has been recognized for its wound-healing properties attributed to its phytoconstituents. The plant contains phytochemicals such as tannins, anthraquinones, quinines, phenols, flavonoids, and alkaloids, which contribute to its therapeutic effects.^[102]

The ethanolic extract of *H. rosa-sinensis* flowers was tested for its ability to promote healing in Sprague Dawley rat wound models involving excision, incision, and puncture space. When the extract was added to drinking water at a dose of 120 mg/kg per day, it increased the contraction of the wound and the process of epithelium. Additionally, the extract showed increased hydroxyproline concentration, cellular granulation, and strength that breaks the skin.^[103] The impact of a cream [5 and 10% w/w] containing an ethanol extract of *H. rosa-sinensis* flower has been studied in models of dead space, incision, and excision in wistar rats. The extract improved wound contraction and epithelization in the excision wound model, and elevated strength that breaks wound in the incision wound model. The extract enhanced the hydroxyproline concentration and proliferative tissue weight in the dead region wound.^[104]

Sambucus Ebulus

Iran has an extensive distribution of the caprifoliaceous species *Sambucus ebulus*. The plant itself is used in Iranian herbal therapy to treat arthritis and inflammation. Furthermore, this herb works well for *Paederus* dermatitis. According to pharmacological reports, this plant can be helpful for treating rheumatism, burns, wounds, eczema, rashes, and inflammation. It also possesses antibacterial and antioxidant properties^[105,106] Sprague Dawley rats and Swiss albino mice were

used as models for linear incision and circular excision wounds to examine the wound-healing properties of cream made from ethyl acetate, n-hexane and extract of methanol of *S. ebulus* leaves and extracted quercetin 3-O-glucoside. Significant wound healing activity was demonstrated by the ointment containing 1% methanolic extract. The circular excision wound model, it also demonstrated an 84.3% contraction. The tensile power of the wound was also enhanced by the ointment. In all models, quercetin 3-O-glucoside, the isolated chemical, exhibited noteworthy wound healing properties. Wound healing properties were also demonstrated by several subfractions derived from the methanolic extract. Collagen deposition was seen in the excision wound by histopathological analysis^[107]. In addition, the healing process of wounds treated with 2 and 5% ointments comprising a 70% methanolic extract of roots was monitored in Wistar rats at periods of 7, 14, and 21 days. The ointments raised fibroblast count, new capillary production, granulomatous tissue, and epidermal thickness.^[108]

Alchemilla Mollis

The *Alchemilla* genus of plants is a perennial family of Rosaceae plants that is commonly referred to as "Lady's mantle" (ESCOP Monographs, 2003)^[109]. *Alchemilla* species have been utilized to treat rashes on the skin, dermatitis, inflammation of the mouth and throat, dysmenorrhea, and gastrointestinal issues^[110]. *Alchemilla mollis* is traditionally utilized to heal wounds and heavy menstruation^[111-113]. Moreover, phenolic content such as tannins and flavonoids in *A. mollis* has been shown to have antiviral, astringent, diuretic, antispasmodic, and antioxidant properties

Using circular and linear wound models, the ability of the ointments containing an aqueous-methanol extract of the aerial and roots of *A. mollis* to promote wound healing in Wistar rats has been assessed. The ointment significantly increased the rat's tensile strength (39.3%) and rate of healing contraction (51.4%) in the linear incision and circular wound models, respectively, when compared to the control rat. Additionally, it raised the level of hydroxyproline. A histological

investigation demonstrated collagen synthesis, fibroblast proliferation, epithelization, and neovascularization^[114]

Zanthoxylum Bungeanum

The flowering plant *Zanthoxylum bungeanum* is indigenous to the eastern regions of China and is a member of the Rutaceae family. It produces valuable culinary components like Sichuan pepper^[115]. From *Zanthoxylum bungeanum*, more than 140 compounds, including alkaloids, terpenoids, flavonoids, and free fatty acids, have been isolated. These compounds have been shown to elicit a broad spectrum of biological responses, such as cancer-fighting^[117], analgesic^[116], antioxidant^[118], anti-inflammatory^[119], antifungal, and qualities that prevent asthma^[120]. Fruit husk extracts from *Zanthoxylum bungeanum* have the special ability to lift wrinkles in the skin. Cosmetic makers have noticed that applying topically to the skin causes the subcutaneous muscles to relax, minimizing wrinkles^[121]. Another intriguing characteristic purportedly linked to *Zanthoxylum bungeanum* essential oils is their ability to improve percutaneous medication administration^[122].

CONCLUSION

Since ancient times, a wide variety of plants have been used to cure burns, wounds, and cuts. The present research examined the wound healing characteristics of several medicinal plants and found that they are highly beneficial in accelerating the healing procedure of wounds.

Numerous studies have shown the therapeutic properties of plants, and numerous developed countries use herbal remedies for purposes other than wound healing. The present investigation also included several studies that used different formulations with plant extract and had positive outcomes.

This review demonstrated that flavonoids, tannins, glycosides, vitamin C, and carbohydrates are the primary phytoconstituents that have the ability to promote wound healing. The ability of plants to heal wounds can be employed safely when they include certain phytoconstituents.

These agents work through a variety of mechanisms, including hemostasis, tensile strength stimulation, collagenization, and epithelium creation.. The ability of plants to heal wounds is well-established, and this knowledge may be applied to create novel preparations for wound healing.

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