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MEDICINAL PLANT WITH WOUND HEALING ACTIVITY: A FUNDAMENTAL REVIEW

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ABSTRACT

Wound healing is a process in which the tissue repairs itself after injury. Wound healing has attained a lot of attention as it is a complex phenomenon to maintain the integrity of skin after trauma**.** Plants always had a fundamental importance due to many reasons, and their therapeutic potentialities are noted and applied over generations**.** Recently many medicinal plants have been demonstrated for wound healing potential through in vivo and in vitro preclinical models and their mechanisms of wound healing has also been reported. Electronic databases such as PubMed, Scifinder and Google Scholar were used to search and filter for medicinal plants with wound healing activity. The methods employed in the evaluation of wound healing activity of these plants comprise both *in vivo* and *in vitro* models. *In vivo* wound models such as excision, incision, and burn wound model are commonly employed in assessing the rate of wound closure (contraction), tensile strength or breaking strength determination, antioxidant and antimicrobial activities, histological investigations including epithelialisation, collagen synthesis, and granulation tissue formation. In *in vitro* studies, single cell systems are mostly used to study proliferation and differentiation of dermal fibroblasts and keratinocytes by monitoring typical differentiation markers like collagen. In this study, 55 plants with scientifically demonstrated or reported wound healing properties were reviewed among several authors. The mechanism of wound healing action were by: stimulating neovascularization, antibacterial, free radical scavenging properties (antioxidant), plants anti-inflammatory effect or induction of macrophage cell proliferation, up-regulating the expressions of COL3A, VEGF and basic fibroblast growth factor (bFGF) protein in wound granulation tissue. The study supports the traditional claims of medicinal plant in wound management.

KEYWORDS: wound healing; mechanism of action; medicinal plant; epithelisation.

INTRODUCTION

Wound may be described in different ways but the most common definition is "loss or breaking of cellular and anatomic or functional continuity of living tissues"[1, 2], and it can be broadly categorized as acute or chronic wound.[3, 4] The healing of wound is a complex process. At the time of injury, capillary will be damaged and blood clot is formed. This is followed by an early stage of inflammation. During the early phase of inflammation, cells like neutrophils and monocytes clean bacteria and necrotic tissue through phagocytosis as well as release of enzymes and toxic oxygen products. Subsequently by migration of macrophage to wound area, which marks the transition from early to late phase of inflammation. The next stage is proliferative phase - is characterized by granulation and tissue proliferation formed mainly by fibroblast and the angiogenesis process. Finally, reformulation and improvement in the components of the collagen fiber that increases the tensile strength will occur during the remodeling stage.[3] Thus, alterations in the inflammatory phase will impact the overall integrity. When the healing process is stalled, a chronic wound may develop, and this is more likely to occur in patients with underlying medical disorders. Chronic ulceration commonly affects the lower extremities with a prevalence that ranges between 0.18 and 1.3 percent in the adult population.[5-8] Impaired wound healing cause severe morbidity, requiring patients to stay in the hospital for an extended period of time, a study done in North European countries indicated that foot ulcers cause up to 85% of amputations.[9, 10] many factors can interfere with the wound healing process, thus causing improper or impaired wound healing. The factors include infection, poor nutrition, diabetes, and other diseases,

alcoholism, drugs, smoking, insufficient oxygenation, prolonged inflammation, depression, and others. Impaired wound healing cause severe morbidity, requiring patients to stay in the hospital for an extended period of time. The goal of wound treatment is to lessen the time it takes for a wound to heal and the risk of complications.[11]

In sub-Saharan African and South Asian countries, 1 % to 2 % of the population faces chronic wound at least once in their lifetime.[12,13] More than 1.25 million people sustain burns and approximately 5 million suffer from non-healing wounds each year in the US.[14] The cost of wound care is substantial. Chronic wounds cost European countries 1 % to 2 % of their annual health care budget and $1 billion/year in the US.[15] This cost is unthinkable for most people in developing countries suffering from infected wounds.[12] Majority of the population in both developing and some developed countries use traditional medicine for their primary health care.[16, 17] One of the survey conducted by the WHO reports that more than 80% of the world's population still depends upon the traditional medicines for various diseases. In the developed countries 25 percent of the medical drugs are based on plants and their derivatives and the use of medicinal plants is well known among the indigenous people in rural areas of many developing countries.[18] Thus, plant products are considered to be the best and cost-effective alternatives for wound treatment. Thus, the goal of this review is to expound various plants used for the treatment of wound and mechanisms of wound healing action in experimental animal models and a possible development of the new wound healing remedy for human use.

1. *Vernonia auriculifera*

Vernonia is a genus of about 350 species of forbs and shrubs in the family Asteraceae. Some species are known as ironweed. They are found in North America north of Mexico, with the others being found in South America. Different species of *Vernonia* have also been investigated experimentally revealing many properties such as anti-plasmodial, analgesic, anti-inflammatory, antimicrobial, antidiabetic, antioxidant, and antitumor.[19] In Uganda and Kenya, cold water infusion of *V. auriculifera* is taken orally to relieve fever associated with bacterial and viral infections.[20] In Ethiopia, *V. auriculifera*, locally known as "Barewa", is a known medicinal plant for wounds, fever reduction, hepatitis, headaches, venereal diseases, diabetes, and gastrointestinal problems.[21][22]

Ashenafi et al., reported that wounds treated with 2.5% and 5% (w/w) of the ME, the aqueous fraction (AQF), methanol fraction (MEF), and ethyl acetate fraction (EAF) ointments of *Vernonia auriculifera* demonstrated significant wound healing activity, as shown by enhanced wound contraction, a shortened epithelialization time, increased hydroxyproline content, and enhanced tissue breaking strength. The extract and solvent fractions displayed free radical scavenging activity at various doses.[23-25] also reported wound-healing effect of *V. auriculifera* and is documented in different ethno-pharmacological studies, evidence has it that of 5 and 10% w/w ointments of 80% methanolic extract, chloroform, ethyl acetate, and the aqueous faction of *V. auriculifera* leaves were reported to have a good wound healing action in that crude extract ointments have showed statistically significant difference in epithelialization period, ethyl acetate and aqueous fractions ointments in incision wound model showed a statistically significant ($P < 0.001$) increase in tensile. The 10% w/w and 5% w/w ointments of the crude extract showed a significant ($P < 0.001$) increase in breaking strength. In burn wound model, significant reduction in epithelialization period was observed in 5% w/w ($P < 0.05$) and 10% w/w ($P < 0.001$), and the percentage of wound contraction was significantly increased in most of post wounding days by 10% w/w ($P < 0.001$) and 5% w/w ($P < 0.05$) crude extract ointments. All studies reported above by the team of researchers showed wound healing activity in all wound assay. Wound healing action resulted by boosting the formation of blood vessels and fibroblasts, eliminating free radicals, and enhancing the area's ability to contract. The mechanism of wound healing action was by stimulating neovascularization.

2. *Prunus Africana*

Prunus africana (*Pygeum* or *African cherry*) is an evergreen hardwood tree in forest habitats, over 30–60 m in height and up to 1.5 meters in diameter. The fruits are pinkish-brown, bi-lobed, and spherical, measuring approximately 7 mm in length and 1.3 cm in width, and when they are ripe, the thin fruit pulp turns dark red to reddish-brown.[26] The tree is found in the rainforests of the equatorial region in Africa which includes, Angola, Congo, Cameroon, Ghana, Kenya, Ethiopia, Madagascar, Mozambique Malawi, South Africa, Uganda, Tanzania, Zimbabwe, and Zambia[27] Traditional healers across Africa use *P. africana* as a medicine to treat many ailments including diarrhea, dysmenorrhea, epilepsy, impotency, infertility, mental illness, eye disorders, pneumonia, arthritis, hemorrhage, hemorrhoids, hypertension, anthelmintic, anti-inflammatory, antimalarial, anti-rheumatic diseases etc.[28]

In both models, mice treated with 5% (w/w) and 10% (w/w) crude extract ointment exhibited a significant ($p < 0.001$) wound healing activity as evidenced by the increased rate of wound contraction and hydroxyproline content, the reduced epithelialization time, and the higher skin breaking strength. Mice treated with aqueous fraction ointment exhibited a high percentage of wound healing effect among all solvent fractions. The aqueous fraction consisted of higher phenolic (49.71 ± 0.73 mg/g) and flavonoid (39.58 ± 0.27 mg/g) content, while alkaloid (3.89 ± 0.55 mg/g) content was the lowest.[29] The mechanism behind the plant wound healing action is antioxidation.

3. *Vernonia amygdalina*

V. amygdalina is commonly called bitter leaf in English because of its bitter taste.[30] its Family is Asteraceae. Other African common names include Congo Bololo (D. R. Congo), ebicha (Oromo), grawa (Amharic), ewuro (Yoruba), etidot (Efik), onugbu (Igbo), ityuna (Tiv), oriwo (Edo), Awɔnwono (Akan), chusar-doki or shuwaka (Hausa), mululuza (Luganda), labwori (Acholi), olusia (Luo), ndoleh (Cameroon), Umubirizi (Kinyarwanda) and olubirizi (Lusoga). *V.amygdalina* is effective against amoebic dysentery, gastrointestinal disorders, antimicrobial, antimalaria, antiparasitic, antidiabetic, anti-inflammatory, anticancer and antioxidant effect. The antioxidant effect of *V. amygdalina* can be used for the enhancement of immune system through many cytokines (including NF KB, pro-inflammatory molecules) regulation.[31]

Higher rate of wound contraction (P<0.0001), decrease in the period of epithelization (P<0.01) higher wound breaking strength (P<0.0001), and favorable histopathological changes were observed with the ointment containing 5% and 10% hydro-ethanolic extract of leaves. When a wound heals, a series of procedures occur, named epithelialization, wound contraction, collagenization, coagulation, and inflammation[32, 33] Wound contraction and epithelialization are independent of one another and happen concurrently, but coagulation and collagenization are closely connected.[34, 35, 36] Ruslim et al., also reported the sequential effect of VAF methanol extract of the leaves at different doses can accelerate wound healing after tooth extraction of mice. Additionally,[31] Showed there was rapid reduction in the wound size of the guinea pig treated with the medium concentration of the extract and the dermazin cream (positive control), although the dermazin healed neatly, the medium concentration of the extract healed faster. The results obtained encourage the use of the mixture of *v. amygdalina,* palmoil and egg albumin in wound healing. The mechanism of wound healing action of *Vernonia amygdalina* lies in their antibacterial and free radical scavenging properties.[37] Mazumder *et al*.

4. *Acacia Arabica*

Acacia Arabica is in the family of Malvaceae, it can be found in tropical and warm temperate regions around the world, with the highest number of species found in the Americas (185 species), Australia (957 species), Asia (89 species) and Africa (144 species). Acacia arabica has been shown to be useful in the treatment of a number of diseases, including diabetes, skin illness, and, most importantly, cancer. In Indian traditional medicine, the fresh plant parts of Acacia arabica are considered as astringent, aphrodisiac, demulcent, anthelmintic, antidiarrheal, antibacterial.[38][39]

Abdullah et al., 2022 posited by proof that Granulation tissue in the control group was absent after 24h but increased to become profound after 7 days then become moderate, while the study group showed scanty granulation tissue from the first day and increased through study intervals. Re-epithelialization mean scores in the study group were higher than control one. *Acacia arabica* has the efficacy of hastening the wound healing process. Immediately after injury and on subsequent days, all the gel were daily applied topically for 21days or till complete epitheliazation at a dose of 500mg/kg. The wound contraction studies revealed that the wound contraction increases on increasing the concentration of herbal extract.[40][41] and his team showed shortening of activated partial thromboplastin time and prothrombin time of *acacia A* and *Moringa oleifera* and were non-cytotoxic in nature. Both showed antibacterial activity against bacterial organisms known to be involved in wound infections with MIC ranging from 500-600 µg mL^{-1} for GA and 300-700 µg mL^{-1}. The hemostatic character coupled to these properties envisions their potential in preparation of dressings for bleeding and profusely exuding wounds. Also, decrease in inflammatory reaction after seventy-two hours of the wound an caused increase in re-epithelialization rate in wound healing of *acacia nilotica* gel group, so from the study the team of researchers concluded that the acacia plant gel extract has anti-inflammatory effect and accelerate the wound healing of oral mucosa in rabbits. The mechanism of action through which A A improves through the antioxidant capacity[42] Ismail et al. all different studies alludes to the above extract remarkable wound healing action but at different tested dose.

5. ***Rumex abyssinicus***

Rumex abyssinicus Jacq (Family; Polygonaceae) is the most common traditional medicinal plant in the highlands of tropical Africa and distributed throughout North Africa and Ethiopia. In the Ethiopian traditional medicine, the rhizomes of *R. abyssinicus* ("Mekmeko" in Amharic) are used to treat malaria, gonorrhea, poisoning, hepatitis, constipation, sciatic neuralgia, hypertension, migraine, rheumatism, breast cancer, stomach distention, earache, liver diseases, hemorrhoids, typhus, rabies and wound.[43–47]

[48]opined that wound treated with 5 % and 10 % (w/w) hydro-alcoholic extract ointment exhibited significant wound healing activity in both models, as evidenced by increased wound contraction, shorter epithelization time, higher tissue breaking strength and increased hydroxyproline content. The hydroalcoholic extract also produced dose-related significant reduction ($p < 0.05–0.001$) of inflammation. The mechanism of plant action appears to be either the plants anti-inflammatory effect (present study) or induction of macrophage cell proliferation.[46]

6. *Solanum incanum*

(Family: Solanaceae), with a common name of bitter apple and thorn apple. Different parts of it have various ethno-pharmacological uses such as decoction of root and leaf possess analgesic properties while root infusions, leaf paste and pounded fruits are used for

scarifications. Leaf sap have uses in washing of painful areas. Root infusion is used as mouth wash for relief of toothache.[49] Various parts of the plant are also broadly used in the treatment of skin problems, including skin infections, whitlow, burns, sores, ringworm, warts, rashes, wounds, carbuncles, ulcers and benign tumors.[50] Qureshi et al. Observed wound healing through wound contraction and histological parameters. *S. incanum* ointment showed 81% reduction in wound area as compared to negative control where wound area reduced to 22%. The histological analysis further confirmed that ointment favors the tissue regeneration and re-epithelization thus heal wound rapidly as compared to other groups. *S. incanum* is also used in the treatment of sores and wounds in Tanzania.[51,52] also revealed that the methanolic, ethanolic water crude extracts of *S. incanum*, had antibacterial effect on all bacterial pathogens (*Pseudomonas aeruginosa*, *Escherichia coli*, *Proteus mirabilis*, Gram-positive bacteria were observed (*Staphylococcus aureus)* which are microbes present in wound. The methanol crude extract of *S. incanum* had highest zone of inhibition (22±1.15 mm). The results of the present study thus indicate the potential of these medicinal plants in treating some bacterial pathogen found in wound.

7. ***Dodonaea viscosa Jacq***

Dodonaea viscosa Jacq (D. viscosa) (Family: Sapindaceae). *Dodonaea viscosa*, also known as the broadleaf hopbush, is a species of flowering plant in the Dodonaea (hopbush) genus that has a cosmopolitan distribution in tropical, subtropical and warm temperate regions of Africa, the Americas, southern Asia and Australasia. The plant is believed to possess anti-inflammatory, anti-bacterial and antipyretic effects and is traditionally used to treat gout, rheumatism, snakebite, wounds, swellings, and burns.[53-54]

[55] Subramanian et al. opined that *D. viscosa* ointment [DVFO] (2.5% and 5.0% w/w) significantly accelerated wound healing in both models, as demonstrated by quicker wound contraction, epithelialization, elevated hydroxyproline levels and increased tensile strength. Histopathological investigations also revealed that DVFO treatment improved wound healing by re-epithelialization, collagen formation and vascularization of damaged skin samples. Western blot analysis further demonstrated an upregulation of collagen type 3 (COL3A), vascular endothelial growth factor and VbFGF protein in wound granulation tissue of the DVFO-treated group ($p < 0.01$). In another study, the flavonoid from *D. viscosa*, which aids in bacterial eradication, EGF may benefit skin regeneration by promoting cell formation, proliferation, and differentiation.[56] Furthermore,[57] Nayeem et al. also evaluated the wound healing potential of D. viscosa formulation prepared with methanol and chloroform extract of leaves in experimental animals and find it to show a promising wound healing agent. Mechanism of action of *viscosa* ethyl acetate fraction promotes wound healing by up-regulating the expressions of COL3A, VEGF and basic fibroblast growth factor (bFGF) protein in wound granulation tissue.

8. *Bersama abyssinica*

B. abyssinica Fresen Francoaceae family is a shrub approximately 6 meters in height, which is evergreen and common in some African countries including Ethiopia.[58] Fruits powder of *B. abyssinica* mixed with butter has been used to treat eczema.[59] Leaves and roots are used for management of hypertension and cough.[60] Fresh Shoot tip chewed and swallowed for management of Stomachache and squeezed juice applied on the wound.[61] Leaves, roots, barks, and stems decoction were applied on wound.[62] Seed powders were applied on wound and skin burn.[63] [64] Taddese et al. revealed Hydromethanolic crude extract produced 5% (99.5%) and 10% (100%) wound contraction on the 16th day of the treatment and 5% (18.8) and 10% (28.2) percent reduction in the epithelization period on the excision wound healing model. Hydromethanolic crude extract produced 5% (47.5) and 10% (61.17) percent durability on the incision wound healing model. Hydromethanolic crude extract produced 5% (99.82%) and 10% (100%) wound contraction on the 20th day of treatment and 5% (13%) and 10% (21.7%) reduction in the epithelization period on the burn wound healing model, chloroform fraction produced 5% (90.17%) and 10% (91.01%), hexane fraction produced 5% (85.81%) and 10% (86.78%), and aqueous fraction produced 5% (99.17%) and 10% (99.38%) wound contraction on the 14th day of the treatment and 5% (18.8) and 10% (28.2) percent reduction in the epithelization period on the excision wound healing model.

Both hydromethanolic crude extract and solvent fractions at 5% and 10% (w/w) were significant ($p < 0.001$). In another findings, in vitro studies of B. abyssinica hydromethanolic leaves extract that exhibited much higher antibacterial activity against wound infecting pathogenic bacteria, namely; *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumonia.*[65] Alemu, et al., 2024 further showed by evidence that *B. abyssinica* seed extracts (BASE). BASE was found to show promising antibacterial activity against *S. aureus*, *E. coli*, and *P. aeruginosa* (zone of inhibition 15.7 ± 2.5 mm, 16.0 ± 0.0 mm, and 16.7 ± 1.5 mm, respectively).

9. *Jatropha Neopauciflora*

The *Jatropha* genus belongs to the Euphorbiaceae family, one of the most diverse angiosperms and the most used in traditional medicine. Different species of this genus show diverse biological properties, such as *J. gaumeri*, the methanolic extracts of roots and leaves showed antimicrobial and antioxidant activity, respectively.[66] The crude ethyl acetate extract of *J. curcas* bark and mature seed oil showed the highest antimicrobial activity for the Gram-positive

bacteria.[67][68] Reported that *Jatropha Neopauciflora* Pax Latex exhibited Wound-Healing Effect in Normal and Diabetic Mice. At the end of the experiments, him, his team of researchers opined, thus, the skin sections were obtained from the wound area and stained with Hematoxylin-Eosin. Then we counted the number of active fibroblasts in all the experimental groups. In normal mice, the latex accelerated the wound-healing process and decreased the number of active fibroblasts, similarly to Recoveron. In diabetic mice, the latex and Recoveron increased the number of active fibroblasts. In normal and diabetic mice, a thin and orderly epidermis was observed. In a prior study another[69] reported that latex demonstrated antibacterial activity. The most sensitive strains were Gram positive bacteria, particularly *S. aureus* (MIC=2 mg/mL), (wound infesting pathogen) and the latex had bacteriostatic activity. Its mechanism of action is by limiting the risk of several degenerative diseases associated with increased free radicals.[70]

10. *Justicia secunda*

Justicia secunda Vahl belongs to the family Acanthaceae, which is one of the many species of *Justicia* L. plant with stems that sometimes become more or less woody, growing up to 90–200 cm tall. The plant comprises almost 250 genera, with 2500 species. The plant species are widespread in tropical regions and are poorly represented in temperate regions. The leaf decoction of *J. Secunda* is used for the treatment of various ailments including anemia, fever, malaria, cough, anaemia and cold.[71, 72][73] Carrington et al. reported that *J secunda* methanol and acetone extracts with an extraction yield of 15.3% and 0.75%, respectively yielded no activity within the concentration range against the three strains of bacteria tested. Antimicrobial studies by[74] showed no activity against *S aureus* ATCC 29737 bacterium, but activity against *Escherichia coli* (*E coli*), *Bacillus cereus, Pseudomanas aeruginosa* ATCC 25919 and *Candida albicans*. Conversely, studies conducted by[75] produced evidence of activity against *S aureus* ATCC 6538P, but no activity against *E coli* ATCC 0389. The possibility therefore exists that the strain utilized in the experiment is more resistant. The absence of the antimicrobial activity of *J secunda* does not eliminate its possible folklore claim of positive effect of wound healing in general, and therefore its ability to have an effect on diabetic wounds.[76] Bako et al. 2023 also revealed the results of the antimicrobial activity obtained from the fractions of the Stem inhibited or exhibited activity against *Methicillin resist Staph aureus, Vancomycin resistant enterococci, Staphylococcus aureus, Escherichia coli, Klebsiella pneumonia, Helicobacter pylori, Campylobacter fetus, Proteus mirabilis, Pseudomonas aeruginosa*, A possible mechanism by which it may exhibit this effect may be by an antioxidant mechanism such as scavenging free radicals in the wound[77] or providing anti-inflammatory activity.

11. Zehneria scabra

Zehneria scabra is a perennial climbing or trailing herb that belong to the family Cucurbitaceae.[78] The plant is widely distributed in Tropical Africa, and present in Madagascar, India, and in Java, Indonesia. The leaves of *Z. scabra* are used traditionally for wound dressing and healing, treatment of helminthic disease, body swelling, and diarrhea.[79] Roots and leaves are also used to manage fever, common cold, skin problems and stomach pain. It also has antimicrobial activity against the most common bacterial pathogens.[78][80] showed by experiment Parameters such as wound contraction, period of epithelialization, and tensile strength were criteria for determining wound healing action: Upon the application of 10% w/w extract ointment, no signs of dermal toxicity were observed in mice. Both 5% and 10% (w/w) extract ointment formulations increased percentage wound contraction and tensile strength, and shortened the epithelialization period. A recent study confirms the ethanol and ethyl acetate shoot extract of *Z. scabra* have antimicrobial activity against the most common bacterial pathogens, ie, *Staphylococcus aureus* and *E. coli*.[78] Furthermore,[81] also reported wound healing action of *Z. scabra* in rats, a test dose of 2000 mg/kg of the 10% w/w crude extract ointment was found to be safe. Groups treated with the 5%and 10% ethyl acetate fractions of the extract experienced significant ($p<0.05$ and $p<0.01$) wound reduction in the excision wound model. The length of epithelization in groups treated with 10% ethyl acetate fraction and aqueous fractions of *Z. scabra* was statistically significant (p 0.001).

12. *Trichilia dregeana*

Trichilia dregeana Sond is from the family of Meliaceae, which is commonly known as Cape Mahogany and Forest Natal Mahogany in South Africa is a large, up to 35m in height and 1.8m in diameter, evergreen tree which inhabits forests in high rainfall areas. Traditionally, different parts of *T. dregeana* are used for the treatment of wounds[82-84], gonorrhea[85,86][87] Shewaye et al. opined that: Both 5% and 10% (w/w) crude extract ointment (CEO) produced significant ($p < 0.001$) wound contraction and period of epithelialization from day 4 onwards as compared to simple ointment (SO) on both excision and burn wounds, tensile strength was increased significantly ($p < 0.001$) for the CEO-treated mice as compared to both untreated and SO groups. In a study by[88], methanol extracts of *T. dregeana* had weak activity (> 6.25 mg/ml) against *E. coli*, and *S. aureus*. Similar findings was also made by[89] except that the methanol leaf extract had moderate to weak activity against E. coli, *P. aeruginosa* and *S. aureus* respectively. *T. dregeana* showed weak antibacterial action of *B.subtilis, S. aereus, E.coli* and *K. pneumonia*.[90]

13 *Tectona grandis*

Tectona grandis Linn. (Verbenaceae) is a large deciduous tree. Branchlets are quadrangular, channeled

and stellately tomentose. The tree is growing in higher situations, native to central India, Konkan, Western Deccan peninsula, South India and Burma.[91] It is commonly known as sagwan in Hindi, saka in Sanskrit and teak tree in English.[92, 93] The frontal leaves of the plant are widely used in folklore for the treatment of various kinds of wounds, especially burn wounds. They are also useful to treat haemostatic, depurative, anti-inflammatory and vulnerary, leprosy, skin disease, pruritus, stomatitis, indolent ulcer, haemorrhages, haemopstysis and bacterial infection.[94, 95]

Table 1: Medicinal plants possessing wound healing activity and mechanism of action.

S\n	Plant (specie)	Family	Wound model	Wound healing action	Mechanism of action	Reference
1	*Venonia auri culifera*	Asteraceae	Burn wound	Yes	Stimulating Neovscularization	[22] Ashenafi et al., (2023)
2	*Prurus african*	Rosaceae	Excision wound	Yes	antioxidant	[29] Hanbisa et al., 2023
3	*Vernonia amygdalina*	Asteraceae	Incision wound	Yes	Antibacterial and antioxidant	[31] Osuala et al 2021 and [37] Mazumder et al., 2023
4	*Acacia Arabica*	Malvaceae	Incision wound	Yes	Anti-oxidation	[41] Bhatnagar et al., 2013
5	*Solanum incanum*	Solanaceae	Burn wound	Yes	_	[50] Quereshi et al., 2019. [52] Habton and Gebrehiwot 2019
6	*Dodonea vicosa*	Sapindaceae	Excision /incision	Yes	–	[55,57] Subramanian et al 2023; Nayeem et al., 2021
7	*Jatropha Neopaucifera*	Euphorbiacea	Excision	Yes	Anti-oxidation	[69] Hernandez-Hernandez et al., 2021
8	*Justicia secunda*	Acanthaceae	Nil	Yes- Nil	Anti-inflamatory	[73, 76] Carrington et al., Bako et al., 2023
9	*Zehneria scabra*	Cucurbitaceae	Excision	Yes	Nil	[80] Tekleyes et al., 2021
10	*Tectona grandis*	Verbanaeae	Incision/excision	Yes	Anti-oxidation	[94,98-99] Irinmwinuwa et al., 2023, Suma et al., 2018, Soetan, 2008,

[96] and his team evaluated wound healing action of *Tectona grandis* by excision wound and burn wound models, they thus revealed: animals treated with *Tectona grandis* leaf extract showed significant reduction in period of epithelisation and wound contraction 50%. In the incision wound model, a significant increase in the breaking strength was observed. *Tectona grandis* leaf extract treatment orally produced a significant increase in the breaking strength, dry weight and hydroxyproline content of the granulation tissue in dead space wound. Also[97] showed a significant increase in the breaking strength ($p<0.001$) in incision wound model; decrease in period of epithelisation ($p<0.01$) and increase in wound contraction rate ($p<0.001$) in excision wound model in the test group when compared to control group.[98] affirmed to the wound healing activity of *Tectona grandis* using AgNP in excision wound model in wistar male rats was remarkable and equivalent to standard soframycin treatment. The results showed amelioration of excision wounds using green synthesized AgNP could be a novel therapeutic way of improving wound healing in clinical practice.[95] Irinmwinuwa et al. reviewed antibacterial action *Tectona grandis* and reported that the plant exhibited significant antibacterial (*P. aeruginosa and S. aureus*) activity as is evident by a clear zones of inhibition around the discs, the study also showed that there is an antibacterial compound in teak leaf, namely 5-hydroxy-1,4- naphthalendion (juglone).[99] reported a case of a patient who completely got healed post 30 days of treatment after topical application of shaaka taruna patra taila (*Tectona grandis*). The mechanism of wound healing action is due to controlling metabolism and also perform protective role as antioxidants.[100]

CONCLUSION

This present review study supports the folklore claims of medicinal plant in wound management, along with one case report study. It also exposed the mechanisms of recently reported medicinal plants with wound healing action which could be beneficial in therapeutic practice and development of new wound healing drugs for human use. More Studies should be conducted to with certainty identify the exact active ingredient responsible for their mechanism of action.

Conflict of interest: Nil.

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