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Ethno Medicinal Plants Used for Wound Healing Properties in Tinsukia District, Assam: A Comprehensive Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Wound healing is a vital physiological process that helps to retain the integrity of the skin after it has been damaged, whether by accident or by a deliberate operation. In Tinsukia district, Assam, tribal people and folklore traditions employ a wide variety of plants/plant extracts/decoctions or pastes to cure wounds. This study is designed to explore the ethnomedicinal plants used for the wound healing properties by the people of Tinsukia district, Assam. The Documentation of potential ethnobotanical information of traditionally used medicinal plant with wound healing activity will facilitates the scientific evaluation to look forward into a leading scientific prospect for the development of new herbal therapy for wound healing.

Keywords: Medicinal plants; ethnomedicine; wound healing; traditional healthcare; Tinsukia district.

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1. INTRODUCTION

A wound is a disruption of the skin's normal state as a result of damage to its continuity caused by a pathological process, whether internal or external. Wounds are common in everyday life, and they can lead to serious complications, If not treated properly, significant consequences can occur [1].

More than 1.2 million people have died in automobile accidents around the world, with 20-50 million individuals suffering non-fatal injuries such as wounds [2]. Trauma (48.00 percent), foot ulcers (28.00 percent), and pressure sores are the leading causes of acute and chronic injuries in the global population (21.00 percent) [3]. Acute wounds develop quickly and the healing process can be predicted. For instance, injuries sustained as a result of trauma or surgery. The healing process for persistent wounds, such as pressure ulcers, cancer-related lesions, and others, cannot be predicted [4]. In underdeveloped countries, it is estimated that 1-2 percent of the population may experience a chronic injury at some point in their lives [5].

Wound treatment and management are important for both acute and chronic wounds. But chronic wounds are a major source of concern for both patients and clinicians; chronic wounds impact a huge number of patients and significantly diminish their quality of life. According to current estimates, almost 6 million people worldwide suffer from chronic wounds [6].

Wound healing agents research is one of the burgeoning fields in modern biomedical science. Many traditional healers around the world, particularly in countries like India and China, have important knowledge of many lesser-known, previously undiscovered wild plants that are utilized by traditional healers to cure wounds. Several medications of plant, mineral, and animal origin are described in old texts of Indian systems of medicine like Ayurveda for their therapeutic characteristics as 'Vranaropaka.' In addition to the classical systems of Indian medicine, folk and tribal medicine uses a variety of herbs and animal products to treat cuts and wound. Some of these plants have been experimentally examined for wound healing action in various pharmacological models and human patients, but the potential of the majority of them has yet to be discovered [7].

2. WOUND HEALING PROCESS

All of the body's tissues and organs experience wound healing. Many of these repair mechanisms are found in all tissues of the body. While the healing process is continual, it is divided into stages at random to better explain the physiological processes occurring in the wound and surrounding tissue [8]. Healing is a dynamic procedure involving coordinated interactions between many immunological and biological systems. Various stages of the healing process necessitate a series of carefully and precisely managed processes and activities that correspond to the appearance of various cell types in the wound bed. The numerous processes that occur in acute tissue recovery as a result of tissue damage can be grouped into four time-dependent phases: hemostasis, inflammation, proliferation, and remodelling (Table 1) [9].

2.1 Hemostasis

When the skin is wounded, the body's natural reaction to stop bleeding is to constrict the artery walls. Following that, primary and secondary hemostasis are aided by two contemporaneous and mechanistically related mechanisms [8]. For primary hemostasis, platelet aggregation and the formation of platelet plugs inside the sub-endothelial matrix are required. The activation of the coagulation cascade, in which soluble fibrinogen is converted into insoluble strands that make up the fibrin mesh, is referred to as secondary hemostasis. The platelet plug and fibrin mesh unite to create a thrombus, which stops bleeding, releases accompaniments and growth factors, and acts as a temporary scaffold for infiltrating wound-healing cells [10].

2.2 Inflammation

The inflammatory process begins soon after the injury and can persist anywhere from 24 to 48 hours, with some cases lasting up to two weeks. The inflammatory phase quickly starts hemostatic pathways to control the bleeding at the wound site. As a result, clinically discernible cardinal indications of inflammation, skin redness, colour, tumour, pain, and functio-laesa appear [11]. This process is defined by vasoconstriction and platelet aggregation to cause blood clotting and, as a result, vasodilation and phagocytosis to cause inflammation at the wound site [12].

2.3 Proliferation

After persistent damage has stopped, hemostasis has been achieved, and an immune system has been successfully established, the acute wound advances toward tissue repair [13]. On the third day after the damage, the proliferative process begins and lasts for about two weeks. It is defined by fibroblast migration and the deposition of newly produced extracellular matrix, which acts as a replacement for the fibrin and fibronectin provisional network. The macroscopic stage of wound healing can be noticed as an abundance of granulation tissue formation [14].

2.4 Remodeling

In this final stage of wound healing, the granulation tissue goes through a steady decline. The epidermis of skeletal muscle, dermal vasculature, nerves, and myofibers are modified, resulting in the development of functional tissue [15]. The granulation tissue fibroblast and myofibroblast's vascular components are reduced, and PBMC cells die or leave the site. Similarly, the levels of structural and hydration-related glycosaminoglycans and proteoglycans are decreasing. Collagen metalloproteinases produced by fibroblasts and macrophages destroy Type III collagen in granulation tissue and replace it with Type I collagen, which is then rearranged into parallel fibrils, resulting in a low-cellularity scar. This final stage will take months to complete [16].

3. PHYSIOLOGY OF WOUND HEALING

Wound healing is a critical but difficult process in humans and animals, involving a diverse process driven by successive yet overlapping phases such as hemostasis/inflammation, proliferation, and remodelling [24]. Following a skin injury, the exposed sub-endothelium, collagen, and tissue factor activate platelet aggregation, resulting in degranulation and the release of chemotactic factors (chemokines) and growth factors (GFs) to form the clot, and all of the above procedures will achieve successful hemostasis [25]. The first cells to emerge at the injury site, neutrophils, sweep up debris and bacteria to provide a favourable environment for wound healing. Following this, macrophages amass germs and enhance phagocytosis, causing tissue injury. The hemostasis and inflammatory phases can take up to 72 hours to complete [26].

The first cells to emerge at the injury site, neutrophils, sweep up debris and bacteria to provide an ideal environment for wound healing. Macrophages collect germs and facilitate phagocytosis, causing tissue injury. The hemostasis and inflammatory phases usually take 72 hours to complete [27]. The transforming growth factor-b family (TGF-b, which includes TGF-b1, TGF-b2, and TGF-b3), the interleukin (IL) family, and angiogenesis factors (i.e., vascular epidermal growth factor) are all involved in this phase. This stage lasts for days or weeks [28].

The final stage of wound healing is the remodelling phase, which requires a precise balance of existing cell death and new cell creation [29]. In this phase, which lasts a few months or years, the gradual destruction of abundant ECM and immature type III collagen, as well as the formation of mature type I collagen, are crucial. Any deviations during this phase could result in excessive wound healing or chronic wounds [30].

Table 1. Stages of wound healing

S.N.	PHASES	Time of phase	Cells involved	Functions	Ref
1	Hemostasis	Instantaneous	Platelets	Haemorrhage control	[17]
2	Inflammation	2-5 days Some cases (2 weeks)	Neutrophils Macrophages	Removal of cell debris and infection causing agents	[18, 19]
3	Proliferation	3 days to 2 weeks	Lymphocytes Fibroblasts Keratinocytes	Formation of granulation tissue, angiogenesis	[20, 21]
4	Remodelling	21 days to 2 years	Fibroblasts	Collagen formation & scar maturation	[22, 23]

4. WOUND HEALING MANAGEMENT BY MEDICINAL PLANTS

Classical systems of Indian medicine, particularly Ayurveda, Siddha, and Unani, a large number of medicinal plants were used for the treatment of skin diseases such as cuts and wounds. Medicinal plants have been used for centuries to treat a variety of skin and dermatological disorders, particularly cuts, and wounds [31]. The Indian epic Ramayana describes a traditional application of plant-based medicine in the treatment of injuries, When Lord Rama's brother Lakshman was mortally wounded on the battlefield in Lanka, medicinal plants from the Himalayas were used to treat him and return him to fighting strength [32].

People in developed countries are also seeking alternatives to modern wound healing therapies such as antibiotics, corticosteroids, and so on, owing to their side effects. In the case of chronic wound pathogenesis that does not heal, more understanding is required. Pathogenesis and failure to heal are two inseparable aspects that have guarded and heightened the use of herbal drugs as wound healing agent [33].

Various information regarding ethnomedicinal plants with wound healing activity is widely disseminated, with reports in leading journals devoted to ethnobotany and traditional medicine. In this review, we have presented plants that are widely used in traditional in Tinsukia District, Assam and have been reported in ethnobotanical literature for use in wound healing, classifying these plants based on their use in wounds, We have also indicated the same along with the part that have been reported to be used in the healing of the wound. The part used becomes even more important because, in order to provide ethnopharmacological evidence for these plants, researchers must ensure that they use the specific part mentioned in traditional medicines rather than random screening. Table 2 lists some lesser-known plants indigenous to Tinsukia District that are widely used in traditional medicine. It describes the plant, the part used, and the mode of preparation.

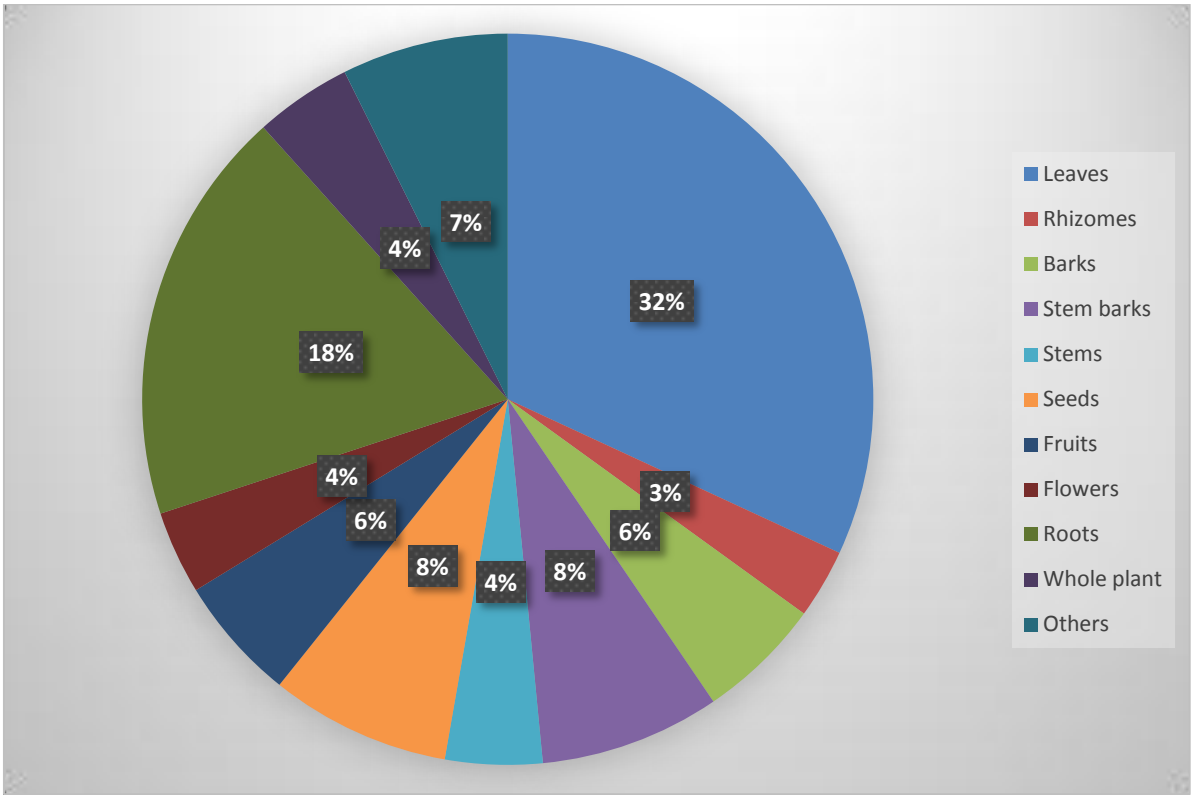

Fig. 1. Percentage of different plant part used for wound healing

Table 2. Ethnobotanical information on wound healing plants available in Tinsukia District, Assam

S.N.	Scientific Name	Family	Local Name	Part used	Mode of preparations
1	*Abies webbianm* Linn.	Pinaceae	Talish	Leaves	The paste of the leaves is applied to wounds.
2	*Abroma augusta* Linn.	Sterculiaceae	Gorokhia korai	Roots	Roots paste is applied on the wounds.
3	*Abrus precalorius* Linn.	Leguminosae	Kunchmoni	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
4	*Acacia catechu* Wild.	Leguminosae	Kher	Stem bark	Stem barks are cut and its juice is applied on the wounds.
5	*Acalypha australis* Linn.	Euphorbiaceae	Kachugaon	Leaves	The paste of the leaves is applied to wounds.
6	*Achyranthus bidentata* Blure	Amaranthaceae	Apamarga	Whole plant	Plant is first grind into paste and then applied on the wounds.
7	*Acorus calamus* Linn.	Acoraceae	Boch	Rhizome& leaves	A paste of rhizome and leaves is applied to wounds.
8	*Adiantum lunulatum* Burm.	Polypodiaceae	Sharujeena	Leaves	The paste of the leaves is applied to wounds.
9	*Aegle marmelos* Linn.	Rutaceae	Bel	Leaves& seeds	Leaves are grind into paste along with black pepper, slightly heated and applied on the wounds.
10	*Ageratum conyzoides* Linn.	Asteraceae	Gundhua bon	Leaves & young shoots	Paste and juice is applied to wounds.
11	*Albizzia lebbeck* Benth.	Leguminosae	Sirish	Roots	Roots paste is applied on the wounds.
12	*Alocasia denudate* Linn.	Araceae	Bon kochu	Stems	Stems are cut and its juice is applied on the wounds.
13	*Aloe vera* Linn.	Asphodelaceae	Sal Kuwori	Leaves	Gel is applied to wounds.
14	*Amaranthus tricolor* Linn.	Amaranthaceae	Bishalya karani	Leaves	Leaf paste is mixed with spit and applied to wounds for quick heal.
15	*Amomum subulatum* Roxb.	Zingiberaceae	Dangor-elachi	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
16	*Anthocephalus cadamba* Miq	Rubiaceae	Kadam	Stem bark	Stem barks are cut and its juice is applied on the wounds.
17	*Aquilaria agalocha* Roxb.	Thymelaeaceae	Agar	Latex	Latex is directly applied to wounds.
18	*Argemone maxicana* Linn.	Papaveraceae	Siyal kata	Roots	Roots paste is applied on the wounds.
19	*Artemesia vulgaris* Linn.	Compositae	Nilum	Stems	Stems are cut and its juice is applied on the wounds.
20	*Azadirachta indica* Linn.	Meliaceae	Neempat	Leaves	Boiled Leaves water are used for washing the wounds. And Leaves paste mixed with mustard oil is also used for wound healing.
21	*Baliospermum monatanum*	Euphorbiaceae	Donti	Leaves	The paste of the leaves is applied to wounds.
22	*Bambusa balcooa* Roxb	Poaceae	Bhalukabanh	Culm	Paste of culm are applied directly on wounds.
23	*Bassia longlifolia* Linn.	Sapotaceae	Mahua	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
24	*Bauhinia purpura* Linn.	Leguminosae	Kanchan	Gum	Gum is directly applied to wounds.
25	*Blechnum Orientae* Linn.	Blechnaceae	Bonoria dhekia	Fronds	Fronds are crushed and is applied on the wounds.
26	*Boerhaavia diffusa* Linn.	Nyctaginaceae	Purnanava	Whole plant	Plant is first grind into paste and then applied on the wounds.
27	*Bridelia retusa* Spreng.	Euphorbiaceae	Kunhi	Bark, fruit	Juice is applied to wounds.
28	*Bryophyllum pinnatum* Kuntz.	Crassulaceae	Dupor Tenga	Leaves	The paste of the leaves is applied to wounds.
29	*Caesalpinia bonducella* F.	Leguminoceae	Letaguti	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
30	*Caesalpinia sappan* Linn.	Leguminosae	Baggam	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
31	*Calamus floribundus*	Arecaceae	Lejai bet	Shoots & roots	Paste is applied to wounds.

S.N.	Scientific Name	Family	Local Name	Part used	Mode of preparations
32	*Callicarpa arborea* Roxb.	Verbenaceae	Bonmola	Barks	The bark is powdered and mixed to form a paste with its juice and applied to wounds.
33	*Calotropis gigantea* Linn.	Asclepidiaceae	Akon	Milky juice	The milky juice is applied to wounds.
34	*Camellia sinensis* Linn.	Theaceae	Sahpat	Leaves	The paste of the leaves is applied to wounds. Decoction also used to heal wounds.
35	*Capparis sepiaria* Linn.	Capparideceae	Gobindaphal	Roots	Roots paste is applied on the wounds.
36	*Carica papaya* Linn.	Caricaceae	Omita	Latex &fruits	Latex is directly applied to wounds.
37	*Catharanthus roseus* Linn.	Apocynaceae	Nayantara	Leaves	The paste of the leaves is applied to wounds.
38	*0drela toona* Roxb.	Leguminosae	Jatipoma	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
39	*Cedrus deodara* Roxb. Loud.	Anonaceae	Devdaru	Leaves	The paste of the leaves is applied to wounds.
40	*Celastrus panniculatus* Wild.	Celastraceae	Politai	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
41	*Centella asiatica* Linn.	Apiaceae	Bor manimuni	Leaves	Leaf paste is applied to wounds.
42	*Chromolaena odorata* Linn.	Asteraceae	Bagh Dhaka bon	Leaves	Leaves paste is applied to wounds.
43	*Cissampelos pareira* Linn.	Menispermaceae	Garialota	Leaves &Stems	Paste of leaves mixed with that of stem is applied in wounds.
45	*Citrullus colocynthis*	Cucurbitaceae	Kuwa-bhaturi	Roots& fruits	Roots paste and fruits juice is applied on the wounds.
46	*Citurs medica* Linn.	Rutaceae	Biratenga	Fruits	Fruits juice is applied on the wounds.
47	*Clitoria terentea* Linn.	Leguminosae	Aparajita	Seeds, Roots & barks	Paste is applied on the wounds.
48	*Crocus sativus* Linn.	Iridaceae	Kesor	Flowers	Paste is applied on the wounds.
49	*Curculigo orchioides* Gaertn.	Hypoxidaceae	Naginipaat	Rhizomes	Powdered dry rhizome is applied in wounds.
50	*Curcuma longa* Linn.	Zingiberacea	Haladhi	Rhizomes	Rhizome is grind into paste and mixed with mustard oil and applied on the wounds.
51	*Curcuma zedoria* Rosc.	Zingiberaceae	Kochura	Tubers	Paste is applied on the wounds.
52	*Cynodon dactylon* Linn.	Poaceae	Dubari bon	Whole plant	Plant is first grind into paste and then applied on the wounds.
53	*Cyperus rotundus* Linn.	Cyperaceae	Keyabon	Roots	Roots paste is applied on the wounds.
54	*Datura fastuosa* Linn.	Solanaceae	Dhutura	Leaves	The paste of the leaves is applied to wounds.
55	*Delonix regia*	Fabaceae	Krishnochura	Leaves	Leaves are crushed and applied on the wounds.
56	*Dillenia indica* Linn.	Dilleniaceae	Otenga	Barks	Barks are dipped in water for overnight and then grind into paste and applied on the wounds.
57	*Drymaria cordata* Linn.	Caryophyllaceae	Lai Jabor	Leaves	Leaves are crushed with spit and applied on the wounds.
58	*Eclipta prostrata* L Linn.	Asteraceae	Keheraj	Roots	Roots are grind into paste and mixed with coconut oil and applied in wounds.
59	*Eletraia cardamomum* Maton.	Zingiberaceae	Elasi	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
60	*Embelia ribes* Burm.f.	Myrsinaceae	Vidang	Fruits	Fruits juice is applied on the wounds.

S.N.	Scientific Name	Family	Local Name	Part used	Mode of preparations
61	*Emblica officinalis* Gaertn.	Euphorbiaceae	Amlokhi	Barks	The crushed bark is applied to wounds.
62	*Eryngium foetidum* Linn.	Apiaceae	Man dhania	Leaves	Leaves juice is applied to wounds.
63	*Euophorbia nerifolia* Linn.	Euphorbiaceae	Sarausiju	Latex	Latex is directly applied to wounds.
64	*Eupatorium odoratum*Linn.	Astraceae	Jarmani bon	Leaves, young shoots	Leaf paste is mixed with spit and applied to wounds for quick heal.
65	*Euphorbia hirta* Linn.	Euphorbiaceae	Paal chedi	Whole plant	Plant is first grind into paste and then the paste is slightly heated and applied on the wounds.
66	*Euphorbia thymifolia*R.Br.	Euphorbiaceae	Gakhiroti-bon	Whole plant	Plant is first grind into paste and then applied on the wounds.
67	*Ficus bengalensis* Linn.	Moraceae	borgos	Stem bark	Stems are cut and its juice is applied on the wounds.
68	*Ficus hispida* Linn.f.	Moraceae	Khoksha-dimoru	Stem bark	Stems are cut and its juice is applied on the wounds.
69	*Ficus lacor* Buch.Ham.	Moraceae	Pakori	Stem bark	Stems are cut and its juice is applied on the wounds.
70	*Firminia coloranta* (Roxb.R. Br.	Sterculiaceae	Odal	Barks & leaves	The paste of the barks and leaves is applied to wounds.
71	*Gloriosa superba*Linn.	Liliaceae	Ulat-chandal	Roots	Roots paste is applied on the wounds.
72	*Glycyrrhiza glabra*	Gabaceae	Jesthimadhu	Roots	Roots paste is applied on the wounds.
73	*Grewia serrulata* DC.	Tiliaceae	Kukurhuta	Leaves	The paste of the leaves is applied to wounds.
74	*Grewia tiliaefolia* VahLinn.	Tiliaceae	Huktapata	Stem bark	Stems are cut and its juice is applied on the wounds.
75	*Gymnema sylvestre* R.Br.	Asclepiadaceae	Madhunashini	Leaves	The paste of the leaves is applied to wounds.
76	*Heliotropium indicu*m Linn.	Boraginaceae	Hati-huria	Leaves	The paste of the leaves is applied to wounds.
77	*Hemidesmus indicus* R.Br.	Asclepiadaceae	Anantamul	Roots	Roots paste is applied on the wounds.
78	*Holarheena antidysenterica* WalLinn.	Apocyanaceae	Dudkhuri	Stem bark	Stems are cut and its juice is applied on the wounds.
79	*Hydrocotyle sibthorpioides* Lamk.	Apiaceae	Khoru manimuni	Leaves	Leaves are grind into paste and mixed with coconut oil and applied to wounds before going to bed atnight.
80	*Hydrolea zeylanica* VahLinn.	Hydrophyllaceae	Leheti-sak	Roots	Roots paste is applied on the wounds.
81	*Icorrhiza kurroa* Royle exBenth.	Scrophulariaceae	Katki	Rhizomes	Powdered dry rhizome is applied in wounds
82	*Imperata cylindrical* (Linn.) Raeusch.	Poaceae	Ulu-bon	Fruits	The powdered dry fruits is applied on wound.
83	*Jasminum auriculatum*VahLinn.	Oleaceae	Khorika jai	Flowers	Paste is applied on the wounds.
84	*Jasminum sambac* Ait.	Oleaceae	Jasmeen	Leaves	The paste of the leaves is applied to wounds.
85	*Justicia gendarussa*	Acanthaceae	Tita bahak	Leaves	The paste of the leaves is used for wound healing.
86	*Kaempferia rotunda LINN.*	Zingiberaceae	Bhumichampa	Tubers	Paste is applied on the wounds.
87	*Lippia nodiflora* Mich.	Verbenaceae	Jal-pipali	Fruits	Fruits juice is applied on the wounds.
88	*Luffa acutangula* Linn.	Cucurbitaceae	Jika	Leaves	The leaf juice is applied to wounds.
89	*Luvunga scandens* Buch.Ham.	Rutaceae	Long-phul	Roots	Roots paste is applied on the wounds.
90	*Melastoma malabathricum* Linn.	Melastomataceae	Phutuki	Barks& roots	The bark and the roots are used for curing wounds
91	*Melocanna baccifera* (Roxb). Kurz.	Poaceae	Tavai	Stems	The glossy surface of stem or cortex is applied to cure wounds.

S.N.	Scientific Name	Family	Local Name	Part used	Mode of preparations
92	*Mesua assami* Linn.	Calusiaceae	Nahar	Flowers & barks	Paste is applied on the wounds.
93	*Microsorum punctatum* (Linn.) CopeLinn.	Polypodiaceae	Kapau dhekia	Leaves	Leaves juice is applied to wounds.
94	*Mikania micrantha* H. B. K	Asteraceae	Japanilota	Leaves	The paste of the leaves is applied to wounds.
95	*Mimosa pudica*	Mimosaceae	Nilaji bon	Leaves	Leaves are crushed along with *Eupatorium odoratum* and applied on the wounds.
96	*Mimusops elengi* Linn.	Sapotaceae	Bokul	Stem bark	Stems are cut and its juice is applied on the wounds.
97	*Morinda citrifolia* Linn.	Rubiaceae	Nuni	Leaves & fruits	The paste of the leaves and fruits is applied to wounds.
98	*Moringa oliefera* Lam.Syn.	Moringaceae	Sajina	Roots	Roots paste is applied on the wounds.
99	*Mucuna pruriens* Bak.	Leguminosae	Bandor-kekua	Roots	Roots paste is applied on the wounds.
100	*Mussaenda roxburghii* Hook. f.	Rubiaceae	Sonarupa	Leaves	Leaves juice is applied to wounds.
101	*Myrica nagi*Thunb.	Myricaceae	Nagatenga	Stem bark	Stems are cut and its juice is applied on the wounds.
102	*Naravelia feylavica(D.C)*	Rananculaceae	Goropsoi	Leaves	The paste of the leaves is applied to wounds.
104	*Nelumbo nucifera* Wild.	Nymphaeaceae	Padam	Stem bark	Stems are cut and its juice is applied on the wounds.
105	*Nicotiana tabacum* Linn.	Solanaceae	Dhapat-goch	Leaves	Leaf is crushed and the juice is applied to wounds
106	*Ocimum sanctum* Linn.	Lamiaceae	Tulsi	Leaves	The paste of the leaves is used for wound healing.
107	*Olea europaea* Linn.	Oleaceae	Jolphai	Leaves	The paste of the leaves is applied to wounds.
108	*Oroxylum indicum* Linn.	Bignoniaceae	Bhat ghila	Seeds & barks	Dry the seeds in the shade, powder it and powder is applied in wounds.
109	*Oxalis corniculata* Linn.	Oxalidaceae	Tengechi-tenga	Leaves	Leaves are grinded into paste and are applied in wounds.
110	*Papaver somiferum* Linn.	Papavaraceae	Afing	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
111	*Parkia roxburghii* G. Don	Mimosaceae	Khorial	Fruits	The green portion of the fruit is mixed with little amount of water and applied to wounds.
112	*Phragmites maxima* Blatte.	Graminae	Nalkhagari	Roots	Roots paste is applied on the wounds.
113	*Piper betle* Linn.	Piperaceae	Paan	Leaves	The paste of the leaves is applied to wounds.
114	*Piper longum* Linn.	Piperaceae	Pipli	Roots	Roots paste is applied on the wounds.
115	*Pluchea lanceolata* Oliver &Hiern.	Compositae	Rasnapat	Leaves	The paste of the leaves is applied to wounds.
116	*Plumbago zeylanica* Linn.	Plumbaginaceae	Bogaagechita	Roots	Roots paste is applied on the wounds.
117	*Pogostemon benghalensis* (Burm.) Kuntze.	Lamiaceae	Sukloti	Leaves	The paste of the leaves is applied to wounds.
118	*Pongamia glabra* Vent.	Leguminosae	Koroch	Seeds & Leaves	The paste of the leaves is applied to wounds.
119	*Pouzolzia zeylanica* (Linn.Benn. & R. Br.	Urticaceae	Borali bukua	Whole plant	Plant is first grind into paste and then applied on the wounds.
120	*Prunus mahaleb*Linn.	Rosaceae	Cherry	Roots	Roots paste is applied on the wounds.

S.N.	Scientific Name	Family	Local Name	Part used	Mode of preparations
121	*Psoralia corylifolia* Linn.	Leguminosae	Habucha	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
122	*Rannunculus scleratus* Linn.	Rannunculaceae	Bon-dhonia	Whole plant	Plant is first grind into paste and then applied on the wounds.
123	*Rhynchostylis retusa* Linn.	Orchidaceae	Kopouphool	Leaves, stems & barks	The paste of the leaves is applied to wounds.
124	*Rubia cordifolia* Linn.	Rubiaceae	Majathi	Roots	Roots paste is applied on the wounds.
125	*Salix tetrasperma* Roxb.	Salicaceae	Bhe	Stem bark & flowers	Stems are cut and its juice is applied on the wounds.
126	*Salmalia malabarica* Schott &EndLinn.	Bombacaceae	Simolu	Stem bark	Stems are cut and its juice is applied on the wounds.
127	*Santalum album* Linn.	Santalanaceae	Chandan	Wood	Powder is mixed with water and applied to wounds.
128	*Saraca indica* Linn.	Leguminoae	Ashok-goch	Stem bark	Stems are cut and its juice is applied on the wounds.
129	*Semecarpus anacardium* Linn.	Anacardaceae	Bor-bhola	Roots	Roots paste is applied on the wounds.
130	*Sesamum indicum* Linn.	Pedaliaceae	Til	Seeds	Dry the seeds in the shade, powder it and powder is applied in wounds.
131	*Shorea robusta Gaertn.f.*	Dipterocarpaceae	*Sal*-goch	Resin	Collected resin is applied to wounds.
132	*Sida cordifolia*Linn.	Malvaceae	Bor Sonborial	Roots	Roots paste is applied on the wounds.
133	*Smilax perfoliata* Lour.	Smilaceae	Tikoniborua	Roots	Root paste is used in the treatment of quick healing of wound.
134	*Spaeranthus indicus* Linn.	Compositae	Bhui-kadam	Flowers	Paste is applied on the wounds.
135	*Spermadictyon suaveolens* Linn.	Rubiaceae	Bon champa	Roots	Roots paste is applied on the wounds.
136	*Spilanthes acmella* (auct.nonLinn. Merr.	Asteraceae	Bonoria malkathi	Fruits	Infusion of fruits is applied to wounds.
137	*Spilanthes paniculata* DC.	Asteraceae	Huhoni	Leaves	Leaves are cooked and taken as food, helps in healing wounds.
138	*Strebulus asper* Lour.	Moraceae	Shoura	Roots	Roots paste is applied on the wounds.
139	*Swertia chirata* Buch.Ham.	Gentianaceae	Chirta	Stems & leaves	The paste of the leaves and stems juice is applied to wounds.
140	*Tagetes erecta* Linn.	Asteraceae	Narji	Leaves	The paste of the leaves is applied to wounds.
141	*Terminaliraia belerica* Roxb.	Combretaceae	Bauri	Fruits	Fruits juice is applied on the wounds.
142	*Thespesia populneaSoland* Ex Correa.	Malvaceae	Paras pipal	Fruits, leaves & roots	The paste is applied to wounds.

5. ETHNOPHARMACOLOGICAL VALIDATION

A number of plants such as Tagetes erecta, Ageratum conyzoides have been reported to offer wound-healing properties. The majority of these investigations include screening plants or extracts for wound healing efficacy on a random basis. We have tabulated (Table 3) some of the plants, which have been pharmacologically validated for their wound healing activity. The models in which these plants and the extracts have been reported for activity are also included in Table 2. This information becomes useful when one considers coming out with a modern medication or formulation utilizing conventional wisdom. Almost all of the plants that have been studied pharmacologically are also used traditionally. Some very common plants like *Aloe vera*, *Azadirachta indica* have been extensively reported in Ayurveda, Siddha and Unani systems of medicines for their wound healing potential.

In animal models (in vivo), a number of secondary metabolites/active chemicals derived from plants have been shown to be active principles responsible for wound healing. Some of the most important ones include asiaticoside, Asiatic acid, and madecassic acid from *Centalla asiatica* (**Ref 58**), curcumin from *Curcuma longa* (**Ref 64**), phenolic acids (protocatechuic, p-hydroxybenzoic, p-coumaric, ferulic and vanillic acids) from *Chromolaena odorata* (**Ref 59**).

Fig: *Aegle marmelos* *(Bel)*

Fig: *Ageratum conyzoides* *(Gundhua Bon)*

Fig: *Piper longum* *(Jaluk)*

Fig: *Alocasia denudata* *(Bon Kochu)*

Fig: *Aloe vera* *(Sal kunwori)*

Fig: *Anthocephalus cadamba* *(Kadam)*

Fig: *Curcuma Longa* *(Halodhi)*

Fig: *Azadirachta indica* *(Neem)*

Fig: *Caesalpinia bonducella* *(Baggam)*

Fig: *Bryophyllum pinnatum* (Dupor tenga)

Fig: *Camellia sinensis* (Sah)

Fig: *Carica papya* (Amita)

Fig:*Catharanthus roseus* *(Nayantora)*

Fig: *Centella asiatica* *(Bor manimuni)*

Fig: *Spilanthes paniculata* *(Huhoni Bon)*

Fig: *Tagetes erecta* *(Naeji ful)*

Fig: *Smilax perfoliata* *(Tikoni Borua)*

Fig: *Rhyncostylis retusa* *(Kopou ful)*

Fig: *Pogostemon benghalensis* (Sukloti))

Fig: *Piper betle* (Pan)

Fig: *Ocimum sanctum* (Tulshi)

Fig: *Mimosa pudica* (Nilai Bon)

Fig: *Mesua assami* (Nahor)

Fig: *Hydrocotyle sibthorpioides* (Horu Manimuni)

Fig: *Eclipta prostrata* (Keheraj)

Fig: *Datura fastuosa* (Dhotura)

Fig: *Dillenia indica* (Otenga)

Fig: *Eryngium foetidum* *(Man dhonia)*

Fig:*Justicia gendarussa* *(Tita Bahok)*

Fig; *Santalum album* *(Chandan)*

Fig: *Amaranthus tricolor* *(Bishalyakarani)*

Fig: *Calamus floribundus* *(Lejai Bet)*

Fig: *Jasminum auriculatum* *(Khorika Jai)*

Fig: *Mikania micrantha* *(Japani Lota)*

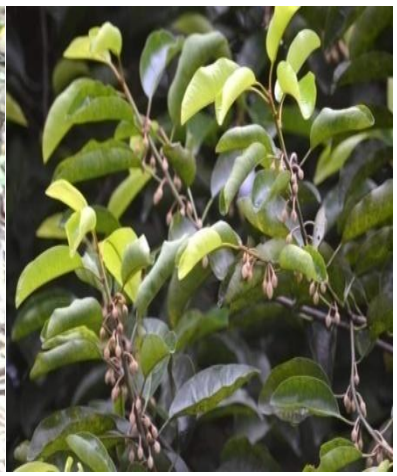

Fig: *Mimusops elengi* *(Bokul)*

Fig: *Olea europaea* *(Jolphai)*

Fig: *Callicarpa arborea* (Bomola)

Fig: *Calotropis gigantea* (Akon)

Fig: *Chromolaena odorota* (Bagh Dhoka)

Fig: *Myrica nagi* (Naga tenga)

Fig: *Oxalis corniculata* (Tengechi)

Fig: *Oroxylum indicum* (Bhat Ghila)

Fig: *Bambusa balcooa* (Bhaluka Bah)

Fig: *Aquilaria agalocha* (Agar)

***Fig: Emblica officinalis* (Amlokhi)**

Fig: *Cedrus deodara* (Devdaru)

Fig: Ficus benghalensis (Borgos)

Fig. 2. Following are some picture of the ethnomedicinal plants available in Tinsukia District, Assam with high efficacy towards wound healing

Table 3. Plants with wound healing activity and their model reported

Name of the plant	Active constituents	Extract/Fraction	Pharmacological profile	Ref
Abroma augusta Linn.	Alkaloids, abromine, sterol, friedelin, β-sitosterol, abromasterol, taraxeryl acetate, taraxerol	Alcoholic root extract	In-vivo (Wistar rats) Incision, excision & dead space wound model	[34]
Acacia catechu Wild.	Glycosides, carbohydrates, proteins, saponins, gums, phytosterols, tannins	Aqueous and alcoholic bark extract	In-vivo (Rats)	[35]
Acorus calamus Linn.	Acorenone, monoterpene hydrocarbons, sequestrine ketones, b-gurjunene, isoshyobunine, alpha-asarone, beta-asarone, calamendiol, a-selinene, a-calacorene, calamusenone, camphone, shyobunone	Ethanolic leaf Extracts	Topical (Wistar albino rats) Incision & excision wound model	[36]
Aegle marmelos	Marmesin, marmin, psoralen, scopoletin, umbelliferone, xanthotoxin	Methanolic and aqueous seeds extract	Topical (Male Wistar rats) Incision & excision wound model	[37]
Ageratum conyzoides	Terpenes, sterols, chromenes, flavoides	Ethanolic leaf extract	Topical (Male Wistar rats) Incision wounds model (tensile strength)	[38]
Albizzia lebbeck	Flavonoids, saponins, phenols, and tannins	Ethanolic root extract	In-vivo (foster albino rats) Incision, excision & dead space wound model	[39]
Alocasia denudata	Steroid, Beta-Sitosterol, Levoglucosan, Beta.-D-Galactofuranose, Alpha.-D-Glucopyranoside, D-Glucopyranose, D-Xylose	Aqueous stem juice	Topical (Male Wistar rats)	[40]
Aloe vera	Vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids, amino acids	Gel	Topical (Female Sprague Dawley rats)	[41]
Anthocephalus cadamba	Triterpenes, tripernoid glycosides, saponins, indole alkaloids cadambine,3a-dihydrocadambine, cadamine, isocadamine and isodihydrocadambine	Aqueous and ethanolic plant extract	Topical (Wistar rats) Incision & excision wound model (tensile strength)	[42]
Artemesia vulgaris	Alkaloids, flavonoids, terpernoids, steroids and tannin	Ethanolic leaf extract	Topical (Guinea Pig)	[43]
Azadirachta indica	Glycosides, diterpenes, triterpenes, flavonoids, steroids	Methanolic leaf extract	Topical (Sprague Dawley male rats) Incision & excision wound model	[44]
Baliospermum monatanum	Flavonoids, alkaloids, tannins, phenolic compounds and steroids	Ethanolic root extract	In-vivo (Albino rats) excision wound model	[45]
Blechnum orientae Linn.	Alkaloids, Tannins, Saponins, Quinones, Terpenoids, Steroids, Flavonoids, Phenol, Coumarins	Methanolic leaf extract	Topical (Sprague-Dawley rats)	[46]
Boerhaavia diffusa Linn.	Amino acids, fatty acids, flavonoid, glycosides, isoflavonoids (rotenoids), steroids (ecdysteroid), alkaloids	Methanol and chloroform leaf extract	In-vitro (cell viability and wound scratch assays) In-vivo excision wound assays in rat models.	[47]
Bridelia retusa.	Tannins, alkaloids, amino acids, flavonoid, glycosides, steroids, Terpenoids	Methanol and aqueous bark extract	Topical (Wistar albino rats) Incision & excision wound model	[48]

Name of the plant	Active constituents	Extract/Fraction	Pharmacological profile	Ref
Bryophyllum pinnatum.	Polyphenols, tannins, glycosaponins, flavonoids, steroidal glycosides	Petroleum ether, alcohol and water leaf extract	In-vivo (albino rats) Excision, resutured incision and Dead space wound model	[49]
Caesalpinia bonducella F.	Alkaloid, phenol, flavonoid, tannin, lignin	Ethyl acetate and methanol leaf, bark and root extract	Topical (Male Wistar albino rats) Excision wound model	[50]
*Caesalpinia sappan*Linn.	Phanginin F, phanginin G, phanginin H, phanginin I, phanginin J , phanginin K, phanginin L, phanginin M, 1naringenin, homoeriodictyol, steraric acid, serlyticin A, kaempferol	Ethanolic extract	In-vivo (Swiss albino mice) Cell proliferation and viability	[51]
Callicarpa arborea.	Bauerenol, β-sitosterol and betulinic acid	Methanolic barks extracts	Topical (rats) Incision, excision & dead space wound model	[52]
Calotropis gigantea Linn.	Cardiac glycosides, flavonoids, terpenoids, alkaloids, tannins, & resins	Ethanolic root bark extract	In-vivo (Wistar albino rats) Incision, excision & dead space wound model	[53]
Camellia sinensis Linn.	Caffeine, gallic acid, catechin, epicatechin, epigallocatechin, epigallocatechin-gallate, epicatechingallate	Methanolic leaf infusion	Topical (male Sprague Dawley rats) Excision wound model	[54]
Carica papaya Linn.	Saponins, Tannins, Triterpenes, Sterols, Alkaloids, Flavonoids	Ethanol seed extract	Topical (Sprague-Dawley rats) Excision wound mode	[55]
Catharanthus roseus Linn.	linolenic acid, ethyl ester, stearic acid, phytol, hexadecanoic acid, limonene, geraniol, citral	Ethanolic flower extract	Topical (Sprague Dawley rats) Incision, excision & dead space wound model	[56]
Celastrus panniculatus Wild.	Alkaloids, glycosides, amino acids, phenolic compounds, tannins, fixed oil, carbohydrates, phenolic compounds, flavonoids, saponins, sterols, triterpenoids	Seed oil gel	Topical (Wister albino rats) Excision and burn wound model	[57]
Centella asiatica Linn.	Terpenes (monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes), phenolic compounds (flavonoids, phenylpropanoids, tannins), polyacetylenes group, alkaloids, carbohydrates, vitamin, mineral and amino acid	Isolated *asiaticoside sterile saline dosage form*	In-vivo & In-vitro (Guinea pig & Sprague Dawley male rats) Chick chorioallantoic membrane and excision wound model	[58]
Chromolaena odorata	Alkaloids, flavonoids, tannins, saponins, terpenoids, anthraquinones, cardiac glycosides and carbohydrates	Aqueous and ethanolic leaf extracts	Topical (Wistar albino rats) Excision wounds model	[59]
*Citrullus colocynthis*schard	Colocynthin, 2,4-di-tert butyl phenol, squalene, ð-tocopherol	Methanolic leaves, stem, root, fruit pulp and seed extract	Topical (Wistar rats) Excision wounds model	[60]
Clitonia ternatea	Flavonol glycoside, phenolic compounds	Seed and root extracts	In-vivo & topical (rats) Incision, excision & dead space wound model	[61]
Crocus sativus.	Crocin, crocetin, picrocrocin, safranal, zeaxanthin	Aqueous ethanolic peel extract	Topical (Male Wistar rats)	[62]

Name of the plant	Active constituents	Extract/Fraction	Pharmacological profile	Ref
Curculigo orchioides.	Phenols, tannins, alkaloids, saponin, flavonoids	Methanolic root extract	In-vivo (Male Swiss albino mice) Excision wounds model	[63]
Curcuma longa Linn.	Curcuminoids, curcumin, demethoxycurcumin, bisdemethoxycurcumin.	Ethanolic root extract	Topical (Rats) Excision wounds model	[64]
Cynodon dactylon Linn.	Carbohydrates, glycosides, flavonoids, saponins, alkaloids, phenolic compounds, tannins, fixed oil, mucilage	Hydroalcoholic whole plant extract	Topical (Male Albino Wistar rats) Excision wounds model	[65]
Cyperus rotundus	Sesquiterpene, cyperene-1, cyperene-2, cyperenone, α-cyperone12, mustakone, β-selinene, sugetriol triacetate, sugenol, copadiene, epoxyguaienerotundone, cyperenol, cyperolone, eugenol, cyperol, isocyperol,	Ethanolic tuber extract	Topical (Male Wistar rats) Incision, excision & dead space wound model	[66]
Datura fastuosa.	Hyoscyamine, hyoscine, atropine, daturilin, cholesterol, sterol, baimantuoluoline A, baimantuoluoline B, daturataturin A	Ethanolic aerial parts extract	Topical (Wistar Albino rats) Excision wounds model	[67]
Delonix regia	Saponins, alkaloids, carotene, hydrocarbons, phytotoxins, flavonoids, tannins, steroids, carotenoids, galactomannon, lupeol, β-sitosterol, terpenoids, glycosides, carbohydrates	Water and ethanol leaf and bark extracts	In-vivo (Albino rats) Incision wound model	[68]
Embelia ribes.	Embelin (3-undecyl 2,5- dihydroxy, 1,4-benzoquinone), an alkaloid christembine, vilangin, 2,5-dihydroxy-4-undecyl-3, 6-benzoquinone	Ethanolic leaf extract	Topical (Male Wistar rats) Incision, excision & dead space wound model	[69]
Emblica officinalis.	Phyllaemblic acid, phyllaemblicin a, phyllaemblicin b, phyllaemblicin c, corilagin, geraniin, gallic acid, phyllanemblinin, ellagic acid, vitamin C	Aqueous and ethanolic bark extract	In-vivo (Wistar rats) Incision & excision wound model	[70]
Euophorbia nerifolia	Flavonoids, saponins, tannins, alkaloids, euphol, neriifoliol, neriifolene, euphorbon, resin, gum, caoutchouc, malate of calcium	Ethanolic leaf extract	In-vivo (Wistar albino rats) Excision & dead space wound model	[71]
*Euphorbia hirta*Linn.	Tannins, triterpenoids, flavonoids and alkaloids.	Ethanol, methanol and water whole plant extract	Topical (Male Wistar rats) Incision & dead space wound model	[72]
Ficus bengalensis.	Alkaloids, flavonoids, saponins, phenols, tannins, diterpenes, phytosterols, proteins, resins	Aqueous leaf extract	In-vivo (Male Sprague dawley rats) Incision, excision & dead space wound model	[73]
Ficus hispida	Glycosides, Carbohydrates, Sterols, Saponins, Tannins, Flavonoids, Triterpenoids	Methanolic leaf extract	In-vivo (Albino Wistar rats) Excision wound model	[74]
Ficus lacor.	Carbohydrates, phenolic, protein,triterpenoids, , free amino acids	Aqueous leaf extract	Topical (Albino Wister rats) Excision wound model	[75]
Grewia tiliaefolia.	Tannins, terpenoids, flavonoids, steroids, saponins,	Methanolic bark extract	In-vivo (Wistar rats) Incision, excision & dead space wound model	[76]
Gymnema sylvestre.	Tannins, flavonoids, phytosterols, cardiac glycosides	Alcoholic leaf extract	In-vivo (Wistar rats) Incision, excision & dead space wound model	[77]
*Heliotropium indicu*m	Alkaloids, Carbohydrates, Gums, mucilages, Proteins, amino acids, Tannins, phenolic compounds, Steroids, sterols Triterpenoids, Saponins ,Flavonoids	Petroleum ether, chloroform, methanol, and aqueous leaf extract	Topical (Wistar albino rats) Incision, excision & dead space wound model	[78]

Name of the plant	Active constituents	Extract/Fraction	Pharmacological profile	Ref
Hemidesmus indicus	Phenols, alkaloids, flavonoids, glycosides, saponins, tannins, phytosterols, terpenoids	Methanolic and aqueous root extract	Topical (Wistar rats) Excision wound model	[79]
Hydrolea zeylanica	Alkaloids, flavonoids, phenols and phenolic compounds, tannins, glycosides, triterpenes, steroids, saponins	Methanolic leaf extract	In-vivo (Wistar albino rats) Excision and incision wound model	[80]
Jasminum auriculatum.	Alkaloids, carbohydrates, tannins, flavonoids, steroids, terpenoids, saponins, phenolic compounds	Petroleum ether, chloroform, ethanol and water leaf extract	Topical (Albino rats) Excision and incision wound model	[81]
Jasminum sambac.	Carbohydrates, flavanoids, steroids, saponins, tannins, phenolic compounds, proteins, amino-acids, glycosides	Aqueous and ethanol leaf extract	Topical (Albino mice) Excision wound model	[82]
Kaempferia rotunda.	Flavonoids, crotepoxid, chalcones, quercetin, sistosterol,stigmosterol, syringic acid, protocatechuic acid	Aqueous and methanol leaf extract	Topical (Wister Albino rats) Excision and incision wound model	[83]
Melastoma malabathricum	Flavonoids, tannins	Aqueous leaf extract	Topical(Sprague Dawley rats) Excision wound model	[84]
Mikania micrantha	Sesquiterpene lactones, phenolic compounds, tannins, flavonoids,	Ethanolic leaf extract	In-vitro Cytotoxicity activity & cell cycle analysis	[85]
Mimosa pudica Linn.	Amino acid (d-Alanin, 1-Alanine ethyl amide), Carbohydrates, Quercetin, D-Pinitol, L-Mimosine, Mimosainic acid, Mimosinamine, P-coumaric acid	Ethanolic leaf extract	Topical (Sprague Dawely rats) Excision & burn wound models	[86]
Mimusops elengi Linn.	Taraxerol, taraxerone, ursolic acid, betulinic acid, V-spinosterol, W-sitosterol, lupeol, mixture of triterpenoid,saponins, alkaloid isoretronecyltiglate	Methanolic stem bark extract	Topical (Albino mice) Incision, excision & dead space wound model	[87]
Morinda citrifolia	Phenols, alkaloids, triterpenoids, steroids, carboxylic acids	Ethanolic leaf extract	In-vivo (Sprague Dawley male rats) Excision & dead space wound model	[88]
Moringa oliefera	Fatty acid, vitamin E, carotenoid, amino acid, glycoside like niazirin I, niazirin II, niazinin, niazimicin, niaziminin	Aqueous leaf extract	In-vivo (Male Swiss Albino Mice) Excision, resutured incision &dead space wound model	[89]

6. CONCLUSION

A number of plants used traditionally and by indigenous peoples have not been validated or examined in light of the traditional claim. The majority of plant/plant extract pharmacological reports test the organic soluble extracts of dried plants for their ability to heal wounds in rats and mice, but the main concern is that the most traditional claims of plants as wound healing agents involve the use of fresh plants as pastes in water. When it comes to wound healing medicines, this is a huge issue because the organic solvent extract of dry plant material is validated, while the aqueous extract of fresh plants is employed; the chemical components will be quite different in both circumstances. In this review, we found that leaf is the most commonly utilized in traditional and tribal medicine to treat wounds (51%), followed by bark and root (19%), flowers and seeds(2%) (Table 1).

Another important issue with pharmacological validation is that the exact mechanism of the wound healing process is unknown; as a result, most researchers limit their plant screening to simple wound healing and do not get into the specifics. It's important to remember that a variety of factors play a role in wound healing, including epithelization, antioxidant defence, and metabolic changes (hydroxyproline). This review will assist pharmacologists in understanding the particular component of the plant and its exact function in traditional medicine, thereby bolstering Ethnopharmacological claims and increasing global acceptance of plant-based wound healing agents.

In addition, there hasn't been a concentrated attempt by researchers to investigate the concept of synergism in wound healing. The synergism of the prospective plants described in this analysis can be used to build a universally accepted wound healing formulation, if properly tested and proven scientifically, can operate as a substitute for or even replace modern wound healing medicines. As a result, the primary goal of this study is to identify and forecast plants, particularly those of Indian origin, that have the potential to become modern medication substitutes.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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