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Review: Ethnomedicinal plants used for wound healing and dermatological problem in the North-Eastern Hill Region of India

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Abstract. *Das G, Thou K, Mondal P, Meeran SM. 2022. Review: Ethnomedicinal plants used for wound healing and dermatological problem in the North-Eastern Hill Region of India. Asian J Ethnobiol 5: 102-119.* Wound healing is a complex process that facilitates tissue cohesion and homeostasis renewal. Medicinal plants have several bioactive compounds and play a principal role in healing and curing human and animal diseases. In our review, we collected ethnobotanical information mostly from Nagaland, a North-Eastern state of India, from various ethnic groups through personal communication, articles, surveys, and sources. In this study, we selected 26 plant species belonging to 20 families categorized as herbs (15 species), shrubs (5 species), trees (4 species), and climbers (2 species) with scientifically demonstrated medicinal properties or reported from ethnic groups on wound healing, dermatological problem, other numerous diseases and disorders relating to the urinary system, inflammation, tumors, diabetes, diarrhea, gastritis, scabies, skin sores, animal/insect bites, parasitic related problems, and rheumatism. They have been compiled and reviewed. Medicinal plants are considered efficacious adjuvants or alternatives to conventional therapies to treat various diseases, and the use of medicinal plants and their products to cure different ailments was reported and recorded. Our review will help create awareness about using medicinal plants and alternative medicine to ameliorate dermatological problems and treat various diseases in humans and animals.

Keywords: Dermatological problems, ethnomedicine, indigenous traditional knowledge, Naga Tribes, wound healing

Abbreviations: AGS: Aged garlic solution; AMR: antimicrobial resistance; cAMP: cyclic adenosine monophosphate; ECM: Extracellular matrix; FGF: Fibroblast growth factors; IGF-1: Insulin-like growth factor-1; IL: Interleukin; ITK: Indigenous traditional knowledge; LDL: Low-density lipoprotein; MDR: multiple drug resistance; NE: North eastern; PBS: Phosphate-buffered saline; PDGF: Platelet-derived growth factor; PFFA: *Paederia foetida* flower absolute; TGF-β: Transforming growth factor beta; TNF-α: Tumour Necrosis Factor-alpha; VEGF: Vascular endothelial growth factor

INTRODUCTION

Nagaland is a state situated in the North-Eastern region of India, bordering the Indian states of Arunachal Pradesh to the north, Assam to the west, Manipur to the south, and the part of Myanmar to the east. The state of Nagaland has a section of 16.579 sq km. and it lies between 25°10'N to 27°4'N longitude and 93°15'E to 95°6'E longitude. The state is generally mountainous except for those areas bordering Assam. Nagaland encompasses a monsoonal climate. Nagaland is presented with a favorable ecological, atmospheric condition-rich repository of biodiversity and medicinal plants. The local tribes use plants that have medicinal properties and values for healing, curing many clinical issues in general and dermatological problems in specific. Medicinal plants became a part of the socio-cultural heritage. These practices have evolved over a protracted period with tests and errors by some ethnic groups and passed on to new generations. World Health Organization (WHO) (2008) defines traditional medicine as 'the health practices, approaches, knowledge, and beliefs incorporating plant, animal and mineral-based medicines, spiritual therapies, manual techniques, and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being. The knowledge of this traditional healing system is as old as humanity and dates back to the start of civilization. Ethno-botanical studies have led to the documentation of conventional and non-conventional medicinal plants utilized by tribals for meeting their multifarious requirements. The tribal people and ethnic races throughout the globe have developed their extensive knowledge of medicinal plants for treating illness (Bhuyan et al. 2014). The state also experiences abundant biological resources and traditional medicinal knowledge, which is advantageous for tribal people (Zhasa et al. 2015).

Despite the bewildering diversity, the ethnicity of Nagaland is blended by different tribes, and the sub-tribe group dates back to the classical era. Nagaland has 16 recognized tribes, and each community has a unique and rich cultural heritage. The social structure, customs, festivals, and beliefs of all communities are different from one another. However, despite the differences, they have been living harmoniously in the state for centuries, and ethnic communities have developed a vibrant stage of

cultural mobility. The Nagas, the people of Nagaland, have ordinarily built their villages on mountain tops where the climate is healthier, pleasant, and self-contained. The villages, fields, and forests provide a wide range of food and spices, raw materials, and ethnomedicine for all kinds of needs of the people. Nagas residing in villages live an elementary life and are mostly farmers, as they yield most of the food and many other essential commodities by themselves. They do not have access to modern medicine due to unavailability and cost, which is one of the main reasons they opt for and practice traditional medicine using plants having medicinal properties. Moreover, it is safe to use, efficacious and economical. Indigenous remedies are gaining recognition among the people of both urban and rural areas. Information from ethnic groups or indigenous traditional medicine has played a vital role in the discovery of novel products from plants. The practice of ethnopharmacology is the pioneer of contemporary medicine.

Medicinal plants have bioactive compounds used for curing various human diseases and play an essential function in healing (Wadood et al. 2013; Putra et al. 2020; Nugroho et al. 2020). The medicinal plant bioactive has a greater role in altering the cell proliferation in wound healing activity (Lordani et al. 2018). Medicinal plants enriched with secondary metabolites harbor potential endophytic microbes involved in various disease pathology. These plants synthesize a diverse array of biologically active compounds essential to survive and flourish within the natural environment, including protective functions concerning abiotic stresses derived from temperature, water, mineral nutrient supply, and bug pests (Egamberdieva et al. 2017). Phytotherapeutic agents are primarily used for cutaneous wound healing and dermatological problems. Medicinal plants can inhibit the expansion of a good range of pathogenic microorganisms because of essential oils (Akhtar et al. 2014). Phytochemicals present in plants are liable for preventing disease and promoting health (Saxena et al. 2013). Changes in temperature associated with climate change are seriously affecting plant architecture, phytochemical composition, flowering, fruiting, and in situ competition with other species as India's climate is chiefly controlled by an annual monsoon, and it appears to be experiencing increasingly severe year after year (Kumar et al. 2017). Since not only are allopathic medicines accessible to tribal populations but their chronic side effects of indiscriminate consumption are well known (Kumarasamayraja et al. 2012). The problem became a spotlight for researchers to resolve the wound infection by using the plant as an alternate solution. Plant products may potentially heal wounds because they promote the repair mechanisms in an exceedingly natural way (Farah et al. 2018).

Wounds types and healing process

A wound is an injury or disruption to the anatomical structure especially epithelial integrity of the skin, even extended in-depth to subcutaneous tissue and other body parts such as ligaments, muscles, blood vessels, nerves, and bone (Robson et al. 2001). According to the healing time frame, wounds are categorized as acute and chronic. Acute wounds can self-repair by following a systematic healing process that restores the anatomical and functional structure. The damage of soft tissue or bone fractures is considered under acute wounds. Usually, healing of acute wounds requires 5 to 10 days or a maximum of 30 days (Velnar et al. 2009). In contrast, chronic wounds fail to process self-repair mechanisms due to various factors such as infection, tissue hypoxia, necrosis, and a surplus of inflammatory cytokines. Chronic wounds require prolonging the time in different phases of the healing process. Among different stages of the wound healing process, prolonged inflammation produces a cascade of tissue which perpetuates a non-healing state, therefore, chronic wounds frequently relapse (Degreef 1998; Robson et al. 2001). Besides a complicated wound is another type of wound that combines an infection and a tissue defect (Bischoff et al. 1999). Infection is always a persistent threat to any wound and can occur due to exposure to different contaminants. Therefore, based on the degree of contamination, wounds are further categorized into three groups: (i) aseptic wounds (bone and joint operations); (ii) contaminated wounds (abdominal and lung operations); and (iii) septic wounds (sores, bowel operations) (Broughton et al. 2006). Wound healing is an intricate process continued with numerous cellular events. Hemostasis, inflammation, proliferation, and dermal remodeling are four distinct overlapping phases of wound healing. Hemostasis is the first stage after injury where vasoconstriction happens, and platelets are activated when interacting with extracellular matrix proteins (ECM) (e.g., fibronectin, collagen, and von Willebrand factor). These ECM proteins enhance cellular migration and interactions with the matrix supporting framework. After activation, platelets discharge some soluble intermediaries such as growth factors (TGF-β, PDGF, IGF-1, VEGF), cAMP, and adhesive glycoproteins, promoting adhesion and aggression. Then, clotting factors are released and form a provisional matrix, where aggregated platelets are trapped and form the bulk of the clot (Gailit et al. 1994). In addition, some clotting enzymes, inactively present in these matrices, are activated and promote the clotting process. In the next phase, inflammation occurs in the first 24 hours, lasts up to 2 weeks in the acute wound, and much longer in a chronic wound. Different immune cells, such as neutrophils, monocytes, and macrophages, release pro-inflammatory cytokines, such as IL-1, IL-6, IL-8, and TNF-α, to clean the wound infection by removing bacteria and denatured matrix components. They also release some growth factors such as PDGF, TGF-β, TGF-α, IGF-1, and FGF to recruit and activate the fibroblasts and epithelial cells to initiate the next phase of proliferation and synthesis of new ECM (Fitridge and Thompson 2011). These growth factors stimulate proliferation, chemotaxis, and collagenase expression of fibroblast. After migration, fibroblast alters their morphology, settles down, and replaces the provisional fibrin matrix with a new matrix of collagen fibers, proteoglycans, and fibronectin. Similarly, injured vasculature also might be replaced by the maintained tissue. After forming a new matrix, epithelialization occurs

where epithelial cells detach and alter their internal structure, migrate, proliferate and differentiate over the granulation tissue to close the wound surface (O'Toole 2001). Matrix remodeling is the final phase of the healing process where granulation tissue matures into scar and tissue tensile strength is enhanced. Simultaneously, the density of fibroblast and capillary decreases, and the scar is replaced by ECM, similar to normal skin, as depicted in Figure 1. ECM remodeling is the result of the balanced, regulated activity of proteases.

Propagating the knowledge of ethnomedicine in North-Eastern hill region

The North-Eastern states of the Republic of India comprise eight states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. It is the state of an outsized range of tribes and represents one of the diverse hotspots of the globe, with the richest plant diversity in India. The tribes of North East India are categorized into completely different ethnic communities. Social folks are the ecosystem folks that live in harmony with nature and maintain an in-depth link between man and the atmosphere. Ethnic groups possess rich knowledge concerning diagnosing and treating significant to minor diseases and are typically specialists in the art of ancient medicine in their community. They conjointly perform varied sorcerous rites and worship for the treatment of diseases. Their knowledge is passed on from generation to generation by oral tradition and, far from the traditional knowledge, has been an unbroken secret to the outside world (Debbarma et al. 2017). In this present era, modern drugs are taking a critical role in treating and curing diseases; however, several tribal communities lack a physiological condition care system. Most tribal economies are engaged in subsistence agriculture and have developed great information on using plants and plant products to cure varied ailments. In addition, the population encompasses a deep belief in their native folklore medicine for remedies (Majumdar and Datta 2007).

In light of the above, our main aim should be to help propagate Indigenous traditional knowledge (ITK) developed by tribals to validate and treat various ailments related to humans and animals. Several of our ethnic groups from NE states are already practicing ethnomedicine and ethnoveterinary practices knowingly or unknowingly. However, the knowledge of these practices must reach the end-user for their benefit. Moreover, multiple drug resistance (MDR) and antimicrobial resistance (AMR) are global concerns. At this juncture, alternative medicinal approaches have been taken up globally as mother nature has endowed the NE states with an abundance of herbal flora, a blessing in disguise.

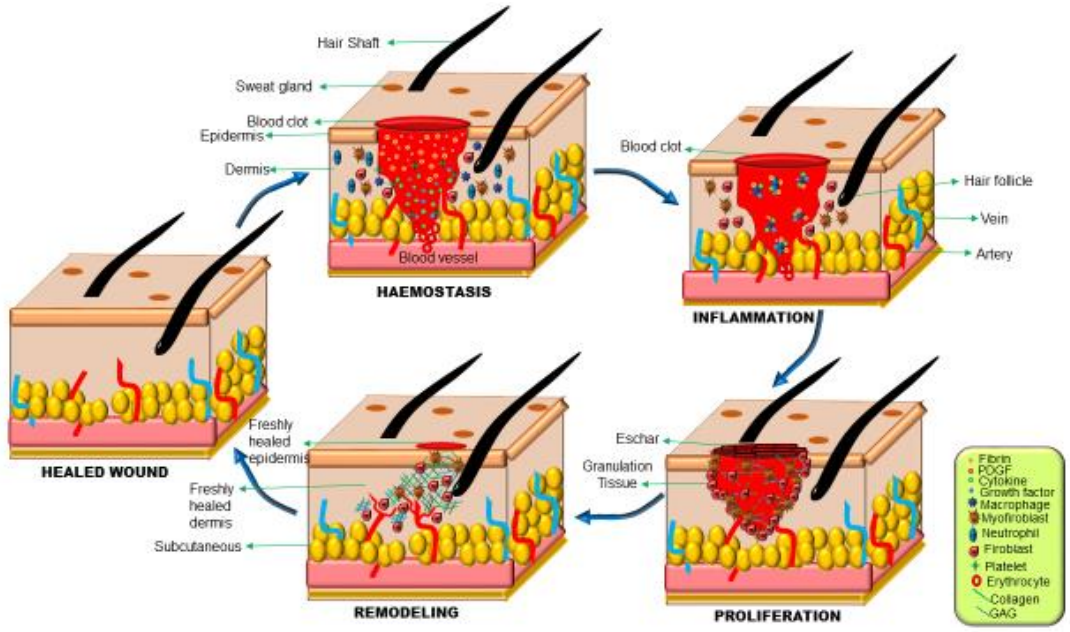

Figure 1. The processes involved in wound healing. The mechanism and stages of the wound healing process. This process will start with hemostasis, where aggregated platelet is trapped and form the bulk of the clot to prevent blood loss. Next, activated platelets release growth factors to promote adhesion and aggression, thereby a provisional matrix is formed. Then during inflammation, different immune cells release pro-inflammatory cytokines for cleaning the wound infection by removing bacteria and denatured matrix components. They also release some growth factors FGF to recruit and activate the fibroblasts and epithelial cells to initiate subsequent phases of proliferation and synthesis of new ECM. After migration, fibroblast alters their morphology, settling down and replacing the provisional fibrin matrix with a new matrix. In the new matrix, epithelial cells detach and change their internal structure, then migrate, proliferate and differentiate over the granulation tissue to close the wound surface. Matrix remodeling is the final phase of the healing process where granulation tissue matures into the scar and the density of fibroblast and capillary decreases. Finally, the scar is replaced by ECM, similar to normal skin.

Commonly used herbs of Nagaland against wound and dermatological problems

This review comprehensively presents the compilation of medicinal plants available in the NE region and their traditional uses for various wound healing activities and dermatological issues. These native medicinal plants are found throughout Nagaland. However, their availability and efficacy vary from season to season and at different altitudes of the region. The plant species' botanical names are organized alphabetically, including the authority and family names followed by their common (local dialect) and English names with their known traditional uses (Figure 2; Table 1).

Ageratum conyzoides *(L.) L.; Asteraceae (Langtampuihei-Zeliang; Pru-Chakesang; Nhasa-Angami; Goatweed/Whiteweed-English)*

The *A. conyzoides* is an erect, herbaceous annual herb. In a few nations, the species is considered a weed, difficult to control its growth. Seeds are positively photoelastic, and viability is regularly lost within 12 months (Marks and Nwachuku 1986; Ladeira et al. 1987). The *A. conyzoides* is extensively applied in traditional medicinal drugs to use diverse cultures worldwide, even though applications range through the region. Locals use this plant to treat pneumonia; however, the most common use is to cure wounds and burns (Ming 1999). Leaf paste is applied to cuts and wounds (Debbarma et al. 2017). The *A. conyzoides* is a local remedy for external ailments like craw-craw, boils, wounds, and leprosy and internally for uterine troubles, purulent ophthalmia, and gynecological diseases. Plant constituents like saponins, phenolics, and flavonoids are ascribed to expedite the stages of wound healing (Dash and Murthy 2011). Leaf paste to cuts and wounds as hemostatic by the Chakesang Tribe of Nagaland (Nelia and Limasenla 2020). The traditional groups have been known to use this species as a bactericide, antidysenteric, and antilithic. The aqueous extract of this plant is used as a bactericide and used to treat fever, rheumatism, headache, cold, and the soup of the whole plant is used to stop dysentery (Ming 1999). Aqueous extract of the entire plant, verified effective clinical control of arthrosis, reporting a decrease in pain and inflammation or improvement in articulation mobility after a week of treatment (Matos 1988). The use of this species in the traditional medicinal drug is significant in Nagaland. According to the ethnic group and older adults of Nagaland, it was reported that the mashed leaves are applied to cuts and injuries by the Angami and Zeliang Tribes of Nagaland (pers. obs.).

Allium sativum *L.; Alliaceae (Naharu-Assamese; Simria-Zeliang; Chiimeria-Angami; Garlic-English)*

The *A. sativum* is commonly used as a culinary spice and is also a known antioxidant. Many tribals cultivate *A. sativum* for their culinary needs and commercial purposes. The *A. sativum* derivatives are often used for antibacterial, antifungal activity, anti-inflammatory, antiparasitic activity, and hypoglycemic properties and have been shown to have a strong anticancer activity (Sidik et al. 2006). It caused an increase in fibrinolytic activity, inhibited platelet aggregation, and lowered cholesterol. It has been used historically to enhance circulation, fit stress and fatigue, and stimulate immune function. Wounds treated with garlic extract and honey significantly accelerate wound healing (Sidik et al. 2006). The ethnic group of the Zeliang Tribe uses root bulbs of garlic, finely crushed and heated with mustard oil to relieve sore throat and the common cold (pers. obs.). It has been shown that sulfur compounds (thiosulfinates) appear to be the active components in the root bulb of the garlic plant. Some studies have suggested that thiosulfinates may be important in preventing bacterial and fungal infections during the wound healing process. Furthermore, it has been demonstrated that sulfur compounds (allicin) stimulate the proliferation of chondrocytes (Santiago et al. 2020). Some findings show that aged garlic solution (AGS) can influence multiple aspects of wound healing and play a vital role in stimulating different cascades of wound healing and angiogenesis (Ejaz et al. 2009). Among various preparations of garlic supplements, it was found that a particular aged garlic solution (AGS) has given sound scientific experiments in wound healing (Ide et al. 1997; Ide and Lau 1999a,b; Ryu et al. 2001).

Aloe vera *(L.) Burm. f.; Asphodelaceae (Alovira-Lotha)*

The *A. vera* treats burns, ulcers, and surgical wounds. The *A. vera* plant possesses astringent, hemostatic, antidiabetic, antiulcer, antiseptic, antibacterial, anti-inflammatory, antioxidant, anticancer, antidiarrhoeal, and wound healing properties (Saini et al. 2016). The *A. vera* has been used for ages and includes the major ingredient in various commercial skin and wound-care products (Dorai 2012). The mucilage content in this plant's leaves, also known as aloe gel, is used for various cosmetics and clinical applications (Hashemi et al. 2015). The *A. vera* leaves pulp was found to have a better and quicker wound healing effect than the standard drug Povidone Iodine ointment (5% w/w) in the excision wound model (Purohit et al. 2012). Fresh aloe leaf is crushed and implemented in the burnt region to get a cooling effect (Jamir et al. 1999). The Chakesang Tribe uses succulent stem juice, which is raw for gastritis and is also applied as a moisturizer on pores and skin dryness (Bharali et al. 2017). According to an ethnic group of Zeliang, Angami, Sumi, Konyak, Lotha, and Rengma Tribes, they use the fresh stem to apply on skin burns, acne, and skin ulcers for quick healing. The raw stem of *A. vera* is also consumed directly to reduce stomach inflammation and expel parasitic worms (pers. obs.). Leaves are used in stomach trouble, purgative, pulp in menstrual disorders, dried juice in constipation, and root in colic disorders (Tripathi et al. 2017). Studies have revealed that treatment with *A. vera* gel accelerated the lesion healing (Liu et al. 2006; Tarameshloo et al. 2012). The *A. vera* has been used for therapeutic purposes by diverse cultures because of its cicatrizing effects (Grace et al. 2008).

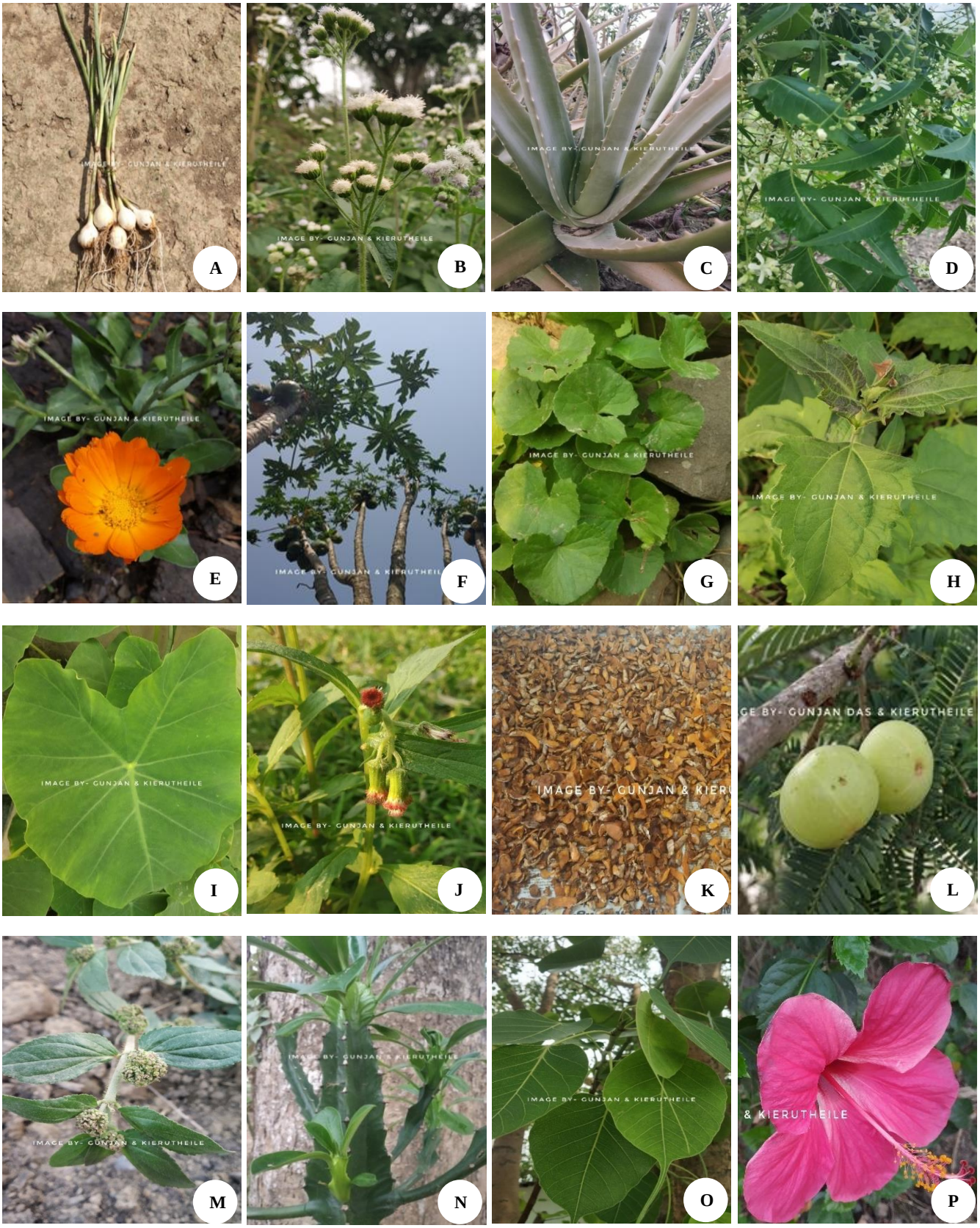
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Figure 2. A. *Ageratum conyzoides*, B. *Allium sativum*, C. *Aloe vera*, D. *Azadirachta indica*, *E. Calendula officinalis*, *F. Carica papaya;* G. *Centella asiatica;* H. *Chromolaena odorata;* I. *Colocasia esculenta;* J. *Crassocephalum crepidioides;* K. *Curcuma longa;* L. *Emblica officinalis;* M. *Euphorbia hirta;* N. *Euphorbia neriifolia;* O. *Ficus religiosa;* P. *Hibiscus rosa-sinensis;* Q. *Kalanchoe pinnata;* R. *Lantana camara;* S. *Leucas aspera;* T. *Mikania micrantha;* U. *Mimosa pudica;* V. *Oxalis corniculata;* W. *Paederia foetida;* X. *Psidium guajava;* Y. *Rubia cordifolia;* Z. *Schima wallichii*

Azadirachta indica *A. Juss.; Meliaceae (Mahanim-Assamese; Jikza-Zeliang; Neem-English)*

The juice of fresh leaves (8-10 drops) of *A. indica* is blended with milk and taken orally to forestall vomiting. Fresh leaf juice is applied in the treatment of aphthae. Dried leaves are powdered and taken (300-400 mg) with water to treat fever related to headaches and treat hypertension (Jamir et al. 1999). The ethanolic extract of *A. indica* has shown wound healing activity in male albino rats (Saini et al. 2016). Fresh leaves are consumed during stomach problems, cough, cold, pimples, fever, smallpox, and chickenpox (Debbarma et al. 2017). The *A. indica* powder, dried in the shade, and mixed with honey, is applied to treat leprosy. Fresh leaf juice is applied on cuts for blood clotting (Tripathi and Srivastava 2010). Leaf, bark, and fruits are used against skin infections and ulcers. It is also an antiseptic and insect repellant (Zhasa et al. 2015). The ethnic group of Nagaland traditionally uses fresh and dried leaves to treat skin diseases and dental disorders, the leaf paste is applied externally on piles by the Zeliang Tribe (pers. obs.).

Table 1. Details of ethnomedicinal plants used for wound healing and dermatological problems in North-Eastern Hill Region, India

Biological name and family name	Vernacular local/English name	Seasonal availability	Methods and parts used	Ailments cured
Ageratum Conyzoides (L.) L.; Asteraceae	Langtampuihei-Zeliang; Pru-Chakesang; Nhasa-Angami; Goatweed/Whiteweed-English	Jun.-Nov.	Mashed leaf is applied topically	Heals wounds, cuts, injuries and stops bleeding
Allium sativum L.; Alliaceae	Naharu-Assamese; Simria-Zeliang; Chiimeria-Angami; Garlic-English	Nov.-Mar.	Finely crushed root bulb, heated with mustard oil is used for massaging and can be eaten	Relief sore throat, common cold and wound
Aloe vera (L.) Burm. f.; Asphodelaceae	Alovira-Lotha	Year-round	Fresh stem is eaten as raw, topically applied on the skin	Treat burns, ulcers, surgical wounds, gastritis and apply as a moisturizer
Azadirachta indica A. Juss.; Meliaceae	Mahanim-Assamese; Jikza-Zeliang; Neem-English	Jan.-Aug.	Juice of fresh leaf blendedwith milk taken orally and leaf paste applied externally	Treat skin, piles, stomach problem and dental disorder
Calendula officinalis L.; Asteraceae	Narji-Assamese; Calendula-Nagamese; Dausure pa-Zeliang; Pot marigold-English	Nov.-May	Decoction of leaf and flower taken orally, leaf paste is applied topically	Treat internal problems, addresses myriad skin complaints
Carica papaya L.; Caricaceae	Mamatsi-Zeliang; Amethi-Lotha; Awathabi-Manipuri; Pawpaw-English	Oct.-Mar.	Crushed seeds made into a paste is applied to the skin, latex is applied topically	Treat skin ulcers, inflammation and fungal infections
Centella asiatica (L.) Urb.; Apiaceae	Hekaraineginei-Zeliang; Gapre-Chakesang; Peruk-Manipuri; Manimuni-Assamese; Gara-Angami; Asiatic pennywort/Indian pennywort-English	Year-round	Aerial part is taken raw, boiled or decoction	Treat skin disorder, skin infection and use as a blood purifier
Chromolaena odorota (L.) R.M.King & H.Rob.; Asteraceae	Chakchakpehei-Zeliang; Siam weed/ Christmas bush-English	Year-round	Leaf paste is applied on fresh cuts and wounds	Heals wounds, cuts, injuries and stops bleeding
Colocasia esculenta (L.) Schott; Araceae	Hebeu-Zeliang; Thomiilabi-Chakesang; Pan-Manipuri; Taro-English	Nov.-Feb.	Boiled corms are edible, the leaf is consumed as stews and soups and stem sap are used	Treat insect sting, cuts, burns, injuries, and internal hemorrhages
Crassocephalum crepidiodes (Benth.) S. Moore; Asteraceae	Heichiu-Zeliang; Ava Tabvo-Chakesang; Ragleaf/ Fireweed-English	Jan.-July	Crushed leaf is applied on wounds and cuts	Heals fresh cuts, wounds and stops bleeding
Curcuma longa L.; Zingiberaceae	Yai-ngang-Manipuri; Haladhi-Assamese; Nagamese-Haldi; Turmeric-English	Dec.-Mar.	Rhizome paste is used to apply on wounds and cuts. Decoction of rhizome is taken orally	Treat wounds, ulcers, cuts, cough, cold, scabies, dysentery and diarrhea
Emblica officinalis Gaertn; Phyllanthaceae	Heigru-Manipuri; Zaunamtsi-Zeliang; Aonla-Chakesang; Indian gooseberry-English	Aug.-Dec.	Crushed bark is used to treat wounds and cuts. Fruits and seeds can be eaten	Treat sores, wounds, cuts. Cures anemia, diarrhea, dysentery and jaundice
Euphorbia hirta L.; Euphorbiaceae	Zawhte-hlo-Mizo; Asthma plant-English	Year-round	Leaf paste is applied topically	Treat coryza, cough, wounds, asthma, injuries and abscesses
Euphorbia neriifolia L.; Euphorbiaceae	Tamrang-Zeliang; Indian spurge tree-English	Year-round	Juice and leaf paste is applied over the skin	Treat skin problems, piles and ulcers

Ficus religiosa L.; Moraceae	Nringbang-Zeliang; Sacred fig-English	Year-round	Leaf paste is applied topically. Bark is used to treat ulcers	Treat burn wounds, skin disease and ulcers
Hibiscus rosa-sinensis L.; Malvaceae	Nuhlupi-Mizo; Jubakusum-Manipuri; Chinese hibiscus-English	Year-round	Flower and leaf stem extracts are used. Mashed leaf is applied on hair	Relief periodic pains, spasms, cough, cold and soothes internal, external wounds and sores
Kalanchoe pinnata (Lam.) Pers.; Crassulaceae	Miruhei-Zeliang; Cathedral bells-English	Year-round	Mashed leaf and flower is applied topically	Heals wounds, burn injury, cuts. Treat sores, stop bleeding, infection and inflammation
Lantana camara L.; Verbenaceae	Nruiteuchi pa-Zeliang; Shrub verbena-English	Year-round	Leaf paste is applied topically. Decoction of mashed leaf and fruit are taken orally	Treat wounds, cuts, ulcers, swellings and relieve gastritis
Leucas aspera (Willd.) Linn.; Lamiaceae	Mi-nkierahei-Zeliang; Thumbai-English	Apr.-Oct.	Leaf plant extracts are taken orally	Treat skin disease, cough, fever, cold and relief inflammation
Mikania micrantha Kunth.; Asteraceae	Nagaria-Zeliang; Bitter vine/Climbing hemp vine-English	Year-round	Leaf juice and mashed leaf is applied topically on fresh cuts and wounds	Heals wounds, cuts and stops bleeding. Treat fever, stings, jaundice, diabetes, itches, cancer and dysentery
Mimosa pudica L.; Fabaceae	Hengamhei-Zeliang; Nilajiban-Assamese; Yikiratera-Lotha; Touch-me-not-English	Year-round	Leaf paste is applied topically. Extract of root and shoot is used to treat wounds	Arrest bleeding, treat cuts, wounds, diarrhea, bleeding piles and boils
Oxalis corniculata L.; Oxalidaceae	Thiizociitu-Chakesang; Nrampuinatangaine-Zeliang; Chingyensil-Manipuri; Tengeshi-tenga-Assamese; Creeping wood sorrel-English	Year-round	Decoction of the whole plant is used and leaf juice is applied topically	It cures skin eruption, burns wounds, sore throat. Treat influenza, snakebite and insect bite
Paederia foetida L.; Rubiaceae	Hebirim ria-Zeliang; Tevuro-Rengma; Stinkvine-English	Year-round	Decoction of mashed leaf and the whole plant is used to apply on swollen sprained joints and wounds	Treat asthma, bowel compliant, piles, diarrhea, promote skin wound restoration, diabetes, urinary retention and joints
Psidium guajava L.; Myrtaceae	Bamgotsi-Zeliang Pongtol-Manipuri; Guava-English	Aug.-Oct.	Leaf paste with few amount of water and oil is applied tothe wound. Raw leaves and fruit are consumed. Root, bark and immature fruit are used	Treat wounds, toothache, ulcers, dysentery, rheumatism and diarrhea
Rubia cordifolia L.; Rubiaceae	Majathi-Assamese; Indian madder-English	Aug.-Nov.	Used as antiseptic for wounds. Root is used for skin complications. Promote complexion	Treat wounds, skin itches, ulcers, eczema, swellings and cancer
Schima wallichii Choisy; Theaceae	Makriasal, nogabhe-Assamese; Khiang/Khainei/Pakhai-Mizo; Needlewood tree-English	Year-round	Juice of stem is used. Crushed fruit is boiled with water to apply in an insect bite. Bark is used as antiseptic	Stops bleeding, heals wounds and cuts. Treat gastritis, uterine issues and hysteria

Calendula officinalis *L.; Asteraceae (Narji-Assamese; Nagamese-Calendula, Dausure pa-Zeliang; Pot marigold-English)*

The *C. officinalis* has been traditionally and widely used in treating inflammations of internal organs, gastrointestinal ulcers and dysmenorrhea and as a diuretic and diaphoretic convulsions. It is also used for inflammations of the oral and pharyngeal mucosa, wounds and burns (Yoshikawa et al. 2001). The *C. officinalis* is a cleansing and detoxifying herb and the infusion treat chronic

infections (Blumenthal et al. 2001). The infusion deal with persistent infections. The dried flower heads were used for antipyretic, antitumor, and cicatrizing effects (Ukiya et al. 2006). The topical application of infusion of flowers is used as an antifungal and antiseptic in wounds, marks, freckles, sprain, and conjunctivitis (Rehecho et al. 2011). It treats various skin tumors, dermatological lesions, ulcers, swellings and nervous disorders (Arora et al. 2013). Mother tincture of *C. Officinalis* is utilized in homeopathy to treat mental tension and insomnia (Boericke 1998). The medicinal properties of *C. officinalis* were stated within the Ayurvedic and Unani medication systems, indicating that leaves and flowers are antipyretic, anti-inflammatory, antiepileptic, and antimicrobial (Kasiram et al. 2000). The *C. officinalis* offered anti-inflammatory and antibacterial activities in addition to angiogenic and fibroblastic properties (Maria et al. 2012). Elderly Zeliang Tribe people of Nagaland use *C. officinalis* as a vulnerary herb and also addresses myriad skin complaints like rashes, stings, wounds, burns, swellings, eczema, acne, insect bites, and bruises (pers. obs.).

Carica papaya *L.; Caricaceae (Mamatsi-Zeliang; Amethi-Lotha; Awathabi-Manipuri; Pawpaw-English)*

The *C. papaya* is traditionally accustomed to treating various skin disorders, as well as wounds. Tribals widely utilize it as a good and readily available treatment option for various wounds and burns (Nayak et al. 2012). The use of *C. papaya* in traditional medicine relies on papain, a proteolytic enzyme, which is the active principle that exerts an ulcer protective effect (Emeruwa 1982). A decoction from the seeds of *C. papaya* has been used to treat skin ulcers and inflammation. Studies suggested that *C. papaya* promotes significant wound healing in rats (Nayak et al. 2012). Seeds are crushed, made into a paste with honey, and applied to the face for pimples treatment (Ranibala and Das 2015). It is known to possess various pharmacologic properties like antioxidant, anti-inflammatory and wound healing (Anuar et al. 2008; Owoyele et al. 2008; Oboh et al. 2013;). Treatment of excision wound with papaya phosphate-buffered saline (PBS) extract (5 mg/ mL) with the addition of selenium (0.5 mg/20 mL) attenuates inflammation associated with oxidative damage and improves cutaneous wound healing (Nafiu and Rahman 2015). Leaves are used for removing corn and warts. Fruit helps in the digestion and flow of urine and constipation. Seeds are used as medicine for cancer treatment by the Sangtam, Angami, Zeliang, and Rengma Tribes of Nagaland (Zhasa et al. 2015). Elderly Zeliang and Rengma Tribes use the latex by applying topically to treat fungal infections and dried latex on the burn wound (pers. obs.). Papaya's anti-inflammatory and antioxidant properties are ascribed to primary and secondary bioactive components like papain, chymopapain, papaya lipase, and carotenoids. Lycopene, β-cryptoxanthin, and β-carotene reportedly have rich carotenoids in papaya fruit with proven antioxidant properties in the biological system (Rivera-Pastrana et al. 2010).

Centella asiatica *(L.) Urb.; Apiaceae (Hekaraineginei-Zeliang; Gapre-Chakesang; Peruk-Manipuri; Manimuni-Assamese; Gara-Angami; Asiatic pennywort/Indian pennywort-English)*

The *C. asiatica* is found throughout the year and grows well in damp, shady places, streams, and ponds. Some locals use the juice of the leaves (3-4 teaspoon) with an equal quantity of milk to treat diarrhea (Jamir et al. 1999). The entire plant is used in skin disorders, syphilis, rheumatism, leprosy, epilepsy, and nervous and immune system disorders (Zhasa et al. 2015). Triterpenes isolated from *C. asiatica* elevate collagen remodeling and glycosaminoglycan synthesis in a rat wound model. It has also been shown to facilitate scleroprotein synthesis and angiogenesis (Maquart et al. 1999; Liu et al. 2008). Local healers of the Zeliang Tribe used the whole plant for skin disorders and skin infections as a blood purifier by smashing the whole parts of the plant and drinking its decoction (pers. obs.). To treat sore throat/hypertension certain amount of the whole plant is boiled with about 2 liters of water and had as a decoction with a glassful 3 times a day. Repeat it till it is cured. One may have fresh leaves regularly as a culinary item to reduce hypertension or high blood pressure (Yuhlung and Bhattacharyya 2016). The *C. asiatica* can promote wound healing by inhibiting inflammation, promoting angiogenesis, inducing collagen synthesis, persuading vasodilation, and reducing wound oxidative stress. The extracts of *C. asiatica* have been shown to affect cell growth and proliferation in injured tissues (Somboonwong et al. 2012). The *C. asiatica* is suggested for treating several skin conditions like leprosy, lupus, varicose ulcers, eczema, psoriasis, diarrhea, fever, amenorrhea, diseases of the female genitourinary tract and also for relieving anxiety and improving cognition (Gohil et al. 2010).

Chromolaena odorata *(L.) R.M.King & H.Rob.; Asteraceae (Chakchakpehei-Zeliang; Siam weed/Christmas bush-English)*

The *C. odorata* leaves are crushed and applied to wounds and cuts. Crushed leaves are also applied around the anus against pinworms. It is also effective for clotting blood from cuts and wounds (Bhardwaj and Gakhar 2005). The performance of healing wounds might be due to the antioxidant property of the plant, which enhances conserving the fibroblast and keratinocyte proliferation in wounds (Vaisakh and Pandey 2012). The *C. odorata* is popularly used for traditional wound healing, and the leave aqueous extract has been used to treat soft-tissue burns or skin infections (Anushik and Wannee 2017). The *C. odorata* promotes wound healing by stopping bleeding, which can be the first step in healing (Anushika and Wannee 2017). Ethnic groups of Zeliang, Angami, and Chakesang Tribes use the leaves paste to heal fresh cuts and wounds to stop bleeding (pers. obs.). The fresh leaves of *C. odorata* by decoction have been used by traditional practitioners for treating human burns, soft tissue wounds, ulcerated wounds, burn wounds, postnatal wounds and also for treating leech bites, indigestion, and skin infection (Panyaphu et al. 2011). The decoctions of the stems of *C.*

odorata were reported to be effective in treating skin diseases caused by *Propionibacterium acnes* (Pandurangan et al. 2015).

Colocasia esculenta *(L.) Schott; Araceae (Hebeu-Zeliang; Thomiilabi-Chakesang; Pan-Manipuri; Taro-English)*

The *C. esculenta* is an essential food for millions of people. The leaves are consumed in sauces, purees, stews, and soups. It is also used in wound healing treatment (Gonçalves et al. 2013). The health benefits of taro might be due to its antioxidants and anticancer activities. The *C. esculenta* corms are edible and used by the Sangtam, Angami, and Zeliang Tribes for treating insect stings, cuts, burns, injuries, and internal hemorrhages (Zhasa et al. 2015). Stem sap to a bee sting and insect bites by Chakesang Tribe (Nelia and Limasenla 2020). To heal the spike on heel, *C. esculenta* tuber is cut and pasted or bandaged around the heel for three to four days (Yuhlung and Bhattacharyya 2016). The *C. esculenta* is called 'Kuchu' in Nagaland (pers. obs.). The *C. esculenta* has wound healing potential and can be ascribed to protecting the wound site against oxidative/nitrosative damage and prevention of hyaluronic acid degradation (Gonçalves et al. 2013). The *C. esculenta* leaf extract has antibacterial, antifungal, anti-inflammatory, and antimicrobial effects. Some phytochemicals like saponins and tannins excite the secretion of growth factors that can affect fibroblast proliferation (Li et al. 2016). The *C. esculenta* is also traditionally used as medicine for scarring purposes, from various studies. Many studies also revealed that *C. esculenta* contains bioactive components with some important components like anticancer, antihyperlipidemic, anti melanogenic, wound healing, anti-inflammatory, probiotics, antihypertensive, antioxidants, antimicrobials (Agyare and Boakye 2015; Pereira et al. 2015).

Crassocephalum crepidioides *(Benth.) S. Moore.; Asteraceae (Heichiu-Zeliang; Ava Tabvo-Chakesang; Ragleaf/Fireweed-English)*

The *C. crepidioides* leaf juice is applied regionally to wounds for fast healing (Ranibala and Das 2015). Although there are not several scientific shreds of evidence concerning its wound healing activity, some tribals use it to treat minor wounds. The herb's wound healing effects would possibly support its capacities of antioxidant, anti-inflammation, fibroblast proliferation, and angiogenesis (Can and Thao 2020). Leaf paste to cuts and wounds as hemostatic by the Chakesang Tribe of Nagaland (Nelia and Limasenla 2020). The leaves of *C. crepidioides* are traditionally accustomed to treat indigestion, stomachache, and wound (Lemmens and Bunyapraphatsara 2003; Grubben and Denton 2004; Loi 2004; Adetutu et al. 2011; Owokotomo et al. 2012). The *C. crepidioides* leaf has wound healing activity due to its antioxidant, anti-inflammation, fibroblast proliferation, wound contraction, and angiogenesis effects (Can and Thao 2020). Many bioactive compounds have been found in *C. crepidioides* leaves, including some phenoplast and flavonoid compounds; the essential oil from *C. crepidioides* leaves contain β-cubebene, α-farnesene, and α-caryophyllene (Can and Thao 2020). According to the local tribes and ethnic groups in the NE region, the Zeliang, Angami, Rengma, Yimkhiung and Sumi Tribes use crushed leaves of *C. crepidioides* to heal fresh wounds and cuts (pers. obs.).

Curcuma longa *L.; Zingiberaceae (Yai-ngang angouba-Manipuri; Haladhi-Assamese, Nagamese-Haldi; Turmeric-English)*

The *C. longa* is an antique spice and a beneficial herb of Ayurvedic medicine. Curcumin, a potent antioxidant, is the essential bioactive component of the herb turmeric and possesses anti-inflammatory, anti-platelet, cholesterol-lowering, antibacterial, and antifungal effects. In addition, Curcumin enhances fibroblast proliferation, granulation tissue formation, and collagen deposition in cutaneous wound healing (Shedoeva et al. 2019). Purohit et al. (2013) investigated that ethanolic extract of *C. longa* rhizomes has a better and quicker wound recuperation effect than ointment in the excision wound model.

The tuber is mashed, warmed, and applied on wounds, skin problems, and cuts. Turmeric tuber also can be used as an expectorant. It is antiseptic and may be utilized in ulcers and wounds. The fungicidal activity of turmeric has additionally been proved. Pure turmeric paste product helps treat scabies (Velayudhan et al. 2012). It is also consumed to treat cough and cold. The rhizome is also taken against food poisoning, diarrhea, dysentery, and typhoid (Bhardwaj and Gakhar 2005). To treat pigmentation/ black/ dark spots/ pimples, the rhizome (turmeric) is mixed with little mustard oil, and apply the paste regularly on the area before bedtime (Yuhlung and Bhattacharyya 2016). According to the information gathered from the local tribes and ethnic groups of the NE region, *C. longa* paste (rhizome) is used for treating wounds and cuts by applying topically and treating cold by decoction (pers. obs.).

Emblica officinalis *Gaertn; Phyllanthaceae (Heigru-Manipuri; Zaunamtsi-Zeliang; Aonla-Chakesang; Indian gooseberry-English)*

The crushed bark has been traditionally used to treat wounds, and cuts, whereas the fruits have a laxative impact (Bhardwaj and Gakhar 2005). Fruit extract of *E. officinalis* has been consumed to treat cough, diabetes, cold, and acidity (Bharali et al. 2017). Fruits and seeds are accustomed to curing anemia, dysentery, diarrhea, hemorrhage, eye inflammation, jaundice, leucorrhoea and menorrhagia, and injury wounds. The inner tender barks are scraped and applied to the wound to tighten the muscles and cure the injury, used by the Lotha and Ao Tribes of Nagaland (Zhasa et al. 2015). The *E. officinalis* is used to defend the skin from the devastating effects of free radicals, non-radicals, and transition metal-induced oxidative stress and has been reported for antimicrobial activities. The juice of the leaves could be an excellent application to sores. It possesses antioxidant, anticancer, antitumor, antigenotoxic, and anticarcinogenic effects and different medical specialty or biological activities. It is considered a secure herbal medicine without adverse effects (Jain et al. 2016). From the survey, it was reported

from an ethnic group that fruits of *E. officinalis* are eaten to treat high blood pressure, act as a blood purifier, and help in digestion (pers. obs.). The bark and leaf paste of *E. officinalis* is applied to the allergic-affected area daily until it cures (Policepatel and Manikrao 2013).

Euphorbia hirta *L.; Euphorbiaceae (Zawhte-hlo-Mizo; Asthma weed-English)*

The *E. hirta* is a small, upright, or ascending annual herb up to 50 cm in height and has hairy stems. The *E. hirta* leaves treat coryza, cough, asthma, bronchial infections, intestinal discomfort, helminth infestations, wounds, stone kidneys, and abscesses (Kumar et al. 2010). Latex is applied against skin parasites twice a day till it is cured. Latex is also applied to destroy warts (Tripathi and Srivastava 2010). The *E. hirta* plant is famous for its medicinal importance in the tribal population and it is a common practice to use the whole plant for wound healing (Tuhin et al. 2017). Aqueous plant extract shows analgesic, antipyretic, anxiolytic, sedative, and medicinal drug activities and additional restrictive action on thrombocyte aggregation. It has been found that the ethanolic extract of the whole herb of *E. hirta* holds important wound healing activity (Nagori and Solanki 2011). Various pharmacological properties, including antiseptic, anti-inflammatory, antidiabetic, antispasmodic, antibacterial, and antiviral, have antifungal, antispasmodic, nootropic, antifertility and aphrodisiac properties of this plant has been reported (Tuhin et al. 2017). The elderly Zeliang Tribe uses the leaf paste of *E. hirta* to treat wounds (pers. obs.). The *E. hirta* has been used as a remedy for various skin and dermatological disorders, especially cuts, wounds and burns (Kumar et al. 2007). The ethanolic extract of *E. hirta* significantly reduces free radicals stress and helps prevent inflammation and oxidative damage, eventually promoting wound healing (Tuhin et al. 2017).

Euphorbia neriifolia *L.; Euphorbiaceae (Tamrang-Zeliang; Indian spurge tree-English)*

The *E. neriifolia* grows luxuriously and extensively across Nagaland's dry, rocky, and hilly regions. Bigoniya and Rana (2007) evaluated the wound healing activity of *E. neriifolia* leaf on excision and dead space wound model. The *E. neriifolia* augmented wound contraction and epithelisation with the aid of an enriched amount of protein and hydroxyproline content. Gaur et al. (2009) demonstrated the anti-inflammatory and analgesic impact of the hydroalcoholic leaf extract of this plant. The *E. neriifolia* has extensive applications in traditional medicines, including the treatment of abdominal troubles, bronchitis, tumors, leucoderma, piles, inflammation, spleen enlargement, anemia, cutaneous diseases, ulcers, fever, and chronic respiration troubles. It is an analgesic, hepatoprotective, immunostimulant, anti-inflammatory, wound healing, and radioprotective agent (Thorat and Bolli 2017). Fresh leaf latex is rubbed on the skin to cure wounds and pimples (Tripathi and Srivastava 2010). Traditionally the leaf of *E. neriifolia* is heated and tied over the affected area to relieve ache and inflammation. The fresh juice from the leaf is poured into the ear to deal with an earache. In addition, the juice is used to treat skin warts and arthritis. The milk latex of *E. neriifolia* is applied over warts as a part of the treatment, and the leaf paste is applied over the skin to deal with skin diseases (Thorat and Bolli 2017). According to local healers of Nagaland, they use the milk latex of *E. neriifolia* to apply to different skin problems by Zeliang, Angami, and Rengma Tribes (pers. obs.).

Ficus religiosa *L.; Moraceae (Nringbang-Zeliang; Sacred fig-English)*

The *F. religiosa* is a substantial perennial tree, glabrous when young, found throughout the plains of Nagaland. The plants are mainly used in traditional Indian drugs for various ailments. Traditionally, the bark is utilized as an antibacterial, antiprotozoal, antiviral, astringent, and antidiarrhoeal to treat gonorrhea ulcers (Chandrasekhar et al. 2010). Roots of *F. religiosa* are used in treatment for gout, skin disease, lower back pain, inflammatory disease of the mouth, ulcer, purgative, and leaf juice is used to treat asthma, cough, sexual disorder, diarrhea, hematuria, toothache, eye trouble, wounds, scabies, diarrhea and skin diseases (Chandrasekhar et al. 2010; Makhijia et al. 2010). The *F. religiosa* has medicinal applications for gynecological problems, dysentery, wound healing, inflammatory, analgesic, and anti-lipid-peroxidation activity (Suganthy et al. 2020). The leaves are used for skin diseases and wounds. The leaves are reported to have antivenom activity and are also shown to regulate the menstrual cycle. It is effective against cancer, inflammation, or infectious diseases (Chandrasekhar et al. 2010). The bark of *F. religiosa* has wound healing activity, analgesic, anti-lipid-peroxidation activity, purgative properties (tender shoots), and anti-inflammatory (Roy et al. 2009). Leaves of *F. religiosa* are usually applied to wounds, skin diseases, and scabies (Yadav 2015). The hydroalcoholic extract of *F. religiosa* leaves showed a dose-dependent wound-healing effect on excision, incision, and burn wounds (Chandrasekar et al. 2010).

Hibiscus rosa-sinensis *L.; Malvaceae (Nuhlupi-Mizo; Jubakusum-Manipuri; Chinese hibiscus-English)*

The *H. rosa-sinensis* is an evergreen shrub native to tropical South-Eastern Asia. The flowers of *H. rosa-sinensis* are edible. Traditional texts describe preparations of the leaves and flowers to promote hair growth and prevent greying (Adhirajan et al. 2003). Extracts from *H. rosa-sinensis* have also been found to have antibacterial and wound healing properties (Nayak et al. 2007; Khan et al. 2014). They attenuate inflammation, enhance fibroblast proliferation and collagen deposition, as well as upregulate VEGF and TGFβ1 expression in rat excisional wounds (Shen et al. 2017). Women use leaf juice to treat infertility. The root is used for mouthwash. Bud, root paste, and rice water are prescribed for irregular menstruation (Debbarma et al. 2017). *Traditionally, hibiscus flowers* have been reported to possess antitumor properties as analgesic, antipyretic, anti-asthmatic, and anti-inflammatory agents. Studies have also proved the presence of antioxidant, antifungal, and antimicrobial properties in flowers of *H. rosa-sinensis* (Vastrad and Byadgi 2018). It has various

important medicinal uses for treating wounds, inflammation, fever, coughs, and diabetes (Missoum 2018). Lotha, Sangtam, and Ao Tribes of Nagaland use flowers and stem extracts to relieve periodic pains, spasms, cures sexually transmitted diseases, coughs, and colds. It soothes internal and external wounds, as well as sores (Zhasa et al. 2015). Methanol extracts prepared from the leaves of *H. rosa-sinensis* were shown to have antimicrobial activities (Hemarana et al. 2014).

Kalanchoe pinnata *(Lam.) Pers.; Crassulaceae (Miruhei-Zeliang; Lotsitse-Chakesang; Cathedral bells-English)*

The *K. pinnata* is a succulent plant. The *K. pinnata* is commonly known as a 'Master Herb' or a 'cure for all by a large community of herbal practitioners in the Caribbean region. In traditional medicine, *Kalanchoe* species have been used for various ailments such as infections, rheumatism, and inflammation. It was found that ethanolic extract of *K. pinnata* facilitates significant wound healing. Its wound healing promotion activity could be due to the potential antioxidant activity of the presence of enriched polyphenolic derivatives (Nayak et al. 2010). Leaves are antibacterial; they soothe irritation, inflammatory skin burns, amoebic dysentery, diabetes, and eyes (Zhasa et al. 2015). The leaf extract is used in bloody dysentery (Debbarma et al. 2017). Zeliang, Angami, Rengma, and Konyak Tribes of Nagaland use mashed leaves and flowers to treat sores, and it helps to stop bleeding from wounds, cuts, and burns injuries (pers. obs.). The decoction of the leaf is taken for kidney problems by the Chakesang Tribe (Nelia and Limasenla 2020).

Lantana camara *L.; Verbenaceae (Nruiteuchi pa-Zeliang; Shrub verbena-English)*

The *L. camara* is a flowering ornamental plant abundantly available in Nagaland. The *L. camara* is used in herbal medicine to treat skin itches, as an antiseptic for wounds, and externally for leprosy and scabies (Nayak et al. 2009). Freshly crushed fruits and leaves are applied to wounds. The decoction of mashed leaves and fruits are given to drink to relieve gastritis and is associated with the treatment of colic problem and antispasmodic properties (Zhasa et al. 2015). Fresh leaves of *L. camara* have been traditionally used on measles in some tribes (De Wet et al. 2013). Treatment of the wounds with extract significantly enhanced the rate of wound contraction (98%), collagen synthesis, and decreased mean wound healing time. These studies demonstrate that *L. camara* is effective in healing excision wounds in experimental animals and could be evaluated as a therapeutic agent in tissue repair processes associated with skin injuries (Nayak et al. 2009). The *L. camara* is used traditionally to treat various diseases like cancers, chickenpox, asthma, ulcers, swellings, eczema, tumors, measles, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, and malaria (Farah et al. 2018). Some parts of the plant are used in treating itches, cuts, ulcers, swellings, bilious fever, catarrh, eczema, dysentery, and chest complaints in children (Deena and Thoppil 2000). Externally for leprosy and scabies (Ghisalberti 2000). Plant extracts are used in folk medicine for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, tumors, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, malaria of abdominal viscera (Day et al. 2003; Saxena et al. 2012). Extracts from the leaves exhibit anti-proliferative, antimicrobial, fungicidal, insecticidal, and nematicidal activity (Saxena et al. 1992; Begun et al. 1995; Sharma et al. 1999; Day et al. 2003). The interactions with the ethnic group of the Zeliang Tribe informed that the leaves of *L. camara* are used as an expectorant. The pounded leaves are applied as a paste to heal cuts, ulcers, and local swellings. Another method is using crushed leaves with coconut oil to treat dermatological problems, and whole plant parts are usually used for herbal preparations (pers. obs.). The leaves of the plant are boiled and used for tea, and it is a remedy against cough by decoction and pounded leaves are also used as a lotion for wounds and are applied to cuts, ulcers, and swellings (Verma and Verma 2006).

Leucas aspera *(Willd.) Linn; Lamiaceae (Mi-nkierahei-Zeliang; Thumbai-English)*

The *L. aspera* is an annual, branched, and herbaceous medicinal weed. The plant parts are used traditionally as an antipyretic and insecticidal agent, and the flowers are valued as a stimulant, expectorant, and diaphoretic. The leaves of the plants are also helpful in treating chronic rheumatism, psoriasis, and other chronic skin diseases (Choudhury et al. 2020). Leaf paste is directly consumed, or the leaves are cooked and taken as a vegetable for pain relief, gastric problems, and joint pain with swelling (Debbarma et al. 2017). The plant extracts help to reduce fever, cough, and cold. It is also used to give fragrance to food. The juice of the flowers was used in folklore medicine for intestinal worm infections in children. The leaves are frequently used to heal psoriasis, skin disorder, headaches and to relieve painful inflammations. Traditionally, young vegetative shoots and flowers of *L. aspera* and in combination with an equal amount of fruits of some medicinal plants, are taken orally to cure dysmenorrheal. All the parts of *L. aspera* showed various pharmacological properties (Srinivasan et al. 2011). Ethnic groups of the Zeliang Tribe use the crushed flower to treat colds, injuries and sinusitis. Decoction of flower and leaf is also used to treat cold (pers. obs.).

Mikania micrantha *Kunth; Asteraceae (Nagaria-Zeliang; Bitter vine/Climbing hemp vine-English)*

The *M. micrantha* leaves juice has been traditionally used to fasten the blood clot after cuts and wounds. Leaves are boiled in water, and the water is given to the patient suffering from dysentery (Bhardwaj and Gakhar 2005). Tribals use unique components of *M. micrantha* to treat fever, jaundice, dysentery, rheumatism, diabetes, colds, respiratory diseases, and scorpion stings (Rahim et al. 2012; Rufatto et al. 2012). The *M. micrantha* leaves have been reported as an excellent hemostatic agent (Basumatary et al. 2004; Bhardwaj and Gakhar 2005; Ayyanar and Ignacimuthu 2009; Rai and Lalramnghinglova 2010; Khisha et al. 2012;). The *M. micrantha* is

traditionally used as a medicinal plant for various health conditions worldwide (Sathi et al. 2015). In ethnoveterinary medicine, the plant deals with diarrhea of veterinary animals and repels the body lice of poultry birds (Rout et al. 2010; Saha et al. 2014). The *M. micrantha* indicates its wide range of medicinal properties, including antitumor, anti-inflammatory, and antibacterial activity (Chung et al. 1998; Yao et al. 2004; Banerjee et al. 2014). The local tribes of Nagaland use mashed leaves to apply to fresh cuts, injuries, and wounds to stop bleeding (pers. obs.).

Mimosa pudica *L.; Fabaceae (Hengamhei-Zeliang; Nuovipru-Chakesang; Nilajiban-Assamese; Yikiratera-Lotha; Touch-me-not-English)*

The *M. pudica* is a short prickly plant with branches growing close to the ground. In traditional healthcare systems, *M. pudica* plant leaves, flowers, stems, roots, and fruits treat various ailments. The content material of *M. pudica* is shown to arrest bleeding and fasten the healing process of wounds. Local healers usually recommend this plant for treating cuts, wounds, diarrhea, amoebic dysentery, and bleeding piles. It is likewise utilized in natural preparations for gynecological disorders. It is effective in relieving the symptoms of rheumatoid arthritis (Joseph et al. 2013). Roots and leaves decoction is used to treat leucorrhoea and urinary problems; leaf paste is applied to skin infections (Nelia and Limasenla 2020). All three parts possess medicinal properties and treat biliousness, leprosy, dysentery, vaginal, uterine complaints, inflammations, burning sensation, fatigue, asthma, leucoderma, and blood diseases (Chauhan and Johnson 2009). The *methanolic extract's M. pudica* shoot and root showed very good wound healing activity (Kannan et al. 2009). According to the elderly local tribal people of the Zeliang Tribe, the mashed leaves are used to treat boils and piles (pers. obs.).

Oxalis corniculata *L.; Oxalidaceae (Thiizociitu-Chakesang; Nrampuina-tangaine-Zeliang; Chingyensil-Manipuri; Tengeshi-tenga-Assamese; Creeping wood sorrel-English)*

The *O. corniculata* were substantially utilized in traditional medicine to cure innumerable ailments like skin infections, piles, healing wounds, treating diarrhea, and cure diseases like cancer, anemia, convulsion, and dyspepsia. Modern medicine has recounted many properties like antioxidant properties, antimicrobial, anti-inflammatory, and wound recuperation, in addition to hepatoprotective properties of the extracts of *O. corniculata* (Rashmi and Sahu 2020). The decoction of the plant is taken to treat diarrhea. Leaf juice is used to remove warts and treat wounds and eczema; leaves are crushed and used to wash latex or sap stains from hands (Nelia and Limasenla 2020). To treat arthritis/ rheumatism (joint pain), the leaf part is boiled and served as a decoction, a glass full 2/3 a day till it cures. It may also be served as a culinary item (Yuhlung and Bhattacharyya 2016). The leaves of this plant are used for healing stomach problems and even as antivenom. The whole plant's paste is applied at the site of the snake bite. To get alleviation from inflammation, the poultice of *O. corniculata* leaves may be applied over the inflamed spot. The infusion made from the leaves can be used to get rid of cornea opacities. Additionally, it may be used to cure itchy eyes by pouring a few drops into the eye. The whole plant decoction is used to get relief from throat infections by gargling. The juice of these plant leaves is used to deal with insect bites, skin eruptions, and burns (Rashmi and Sahu 2020). Zeliang and Ao Tribes of Nagaland use the leaf of *O. corniculata* to deal with different illnesses like influenza, urinary tract infection, enteritis, diarrhea, traumatic injuries, sprains, and poisonous snake bites (Bharali et al. 2017). The whole plant of *O. corniculata* is used as a remedy for scurvy, cataract, boil, wound, eczema, dysentery, diarrhea and used as an appetizer (Zhasa et al. 2015).

Paederia foetida *L.; Rubiaceae (Hebirim ria-Zeliang; Tevuro-Rengma; Stinkvine-English)*

The *P. foetida* is a climbing, herbaceous, hairy, and clean thin vine. The indigenous or traditional practitioners use *P. foetida* for the treatment of numerous diseases. In Ayurveda, it is considered an effective plant extract for antiarthritic, antispasmodic, diaphoretic, expectorant, and stomachic. Similarly, it is also utilized in asthma, bowel complaints, diarrhea, diabetes, seminal weakness, etc. It is also reported to be used in gout, vesical calculi, diarrhea, dysentery, piles, irritation of the liver, and emetic. It was used for rheumatism in folkloric, and bark decoction is used as an emetic (Chauhan et al. 2010). The leaves are mashed, boiled, and applied to the abdomen for urinary retention. Decoction of leaves is extensively utilized for urinary retention and urinary bladder stones. Decoction-soaked clothes are applied to the forehead for fevers, sprained joints and consumed simultaneously (Chauhan et al. 2010). The root extract treats pile problems, spleen inflammation, and aches in the chest and liver (Zhasa et al. 2015). Some findings recommend that *P. foetida* Flower Absolute (PFFA) promotes skin wound restoration by stimulating migratory and proliferative activities, collagen synthesis, and skin barrier restoration of epidermal keratinocytes. PFFA can be beneficial for developing agents that enhance skin wound and barrier-repair functions (Kim et al. 2020). Leaf extract is applied to ease ear pain; leaf juice is taken for diarrhea and dysentery (Nelia and Limasenla 2020). According to the local ethnic group, tribal people use the whole plant in soaked clothes by decoction to apply on the swollen sprained joints to relieve pain (pers. obs.). Decoction of leaves is used for antirheumatic baths. Pounded leaves are implemented on the abdomen for flatulence. Decoction of roots has been used for expelling the gases (Chauhan et al. 2010). A study showed that *P. foetida* has high antioxidant activity and suggested that it could be a significant source of natural antioxidant compounds (Osman et al. 2009).

Psidium guajava *L.; Myrtaceae (Bamgotsi-Zeliang; Pongtol-Manipuri; Guava-English):*

The *P. guajava* leaves have been traditionally used for healing various wounds. Tribals use *Psidium*

guajava leaves made into a paste by grinding with little water or oil, and the same was applied to the wound surface (Lam et al. 2016). Tender shoots are taken directly by chewing or paste to treat diarrhea, dysentery, piles, and vomiting (Debbarma et al. 2017). Tannins and flavonoids exhibited faster healing of experimental wounds when applied with the methanolic extract of guava leaves. Many researchers have proved that ointment made from guava leaves can cure wounds far faster than the available medicine (Lam et al. 2016). Roots, bark, leaves, and immature fruits are used as astringent to treat wounds, ulcers, rheumatism, toothache, dysentery, diarrhea, vermifuge, and leucorrhea by the Sangtam and Zeliang Tribes of Nagaland (Zhasa et al. 2015). Raw fresh leaves are chewed to control dysentery. Young shoots and leaves treat diarrhea and dysentery (Singh et al. 2019).

Rubia cordifolia *L.; Rubiaceae (Majathi-Assamese; Indian madder-English)*

The *R. cordifolia* is used by folklore traditions in India to treat cuts, wounds, and burns. The *R. cordifolia* is popular all over the world for its medicinal uses in skin diseases like eczema, dermatitis, skin ulcers, etc. It is traditionally used for various skin diseases (Karodi et al. 2009). It has a variety of uses such as blood purifier, immunomodulator (Joharapurkar et al. 2003), anti-inflammatory (Antarkar et al. 1983) and antioxidant (Tripathi and Sharma 1998). The chiefly valuable plant part is its rootstocks, which contain phytochemicals like anthraquinone, terpenes, glycosides, etc., and are recognized as the active curative agents to wide and diverse forms of ailments (Devi and Seril 2014). Traditionally, it is used in many polyherbal formulations for numerous illnesses and cosmetic preparations due to its anti-inflammatory, antiseptic and galactopurifier activity (Bechtold and Mussak 2009). Roots, leaves, and stems have antibacterial, antifungal, antiseptic, and antidysenteric to prepare phyto medicine used by the Lotha and Ao Tribes of Nagaland (Zhasa et al. 2015). The roots of *R. cordifolia* are used for laxative, analgesic, rheumatism, dropsy, paralysis and intestinal ulcers and its dried stem is used in blood, skin and urinogenital disorders, dysentery, piles, ulcers, inflammations, erysipelas, skin diseases and rheumatism (Khare 2004).

Schima wallichii *Choisy; Theaceae (Makriasal, nogabhe-Assamese; Khiang/Khainei/Pakhai-Mizo; Needlewood tree-English)*

The juice stem of *S. wallichii* is used to stop bleeding from cuts and is additionally used as an antiseptic. The bark is a good antihelminthic and rubefacient. The crushed fruit is boiled with water and applied to treat the bite of spiders, scorpions, etc. (Bhardwaj and Gakhar 2005). The tree is a rich source of tannins and oil. The astringent corollas are used to deal with uterine issues and hysteria. The bark is used as an antiseptic for wounds and sap from the stem is used to treat ear infections (Tribal community of NE region). The Sema Tribe of Nagas uses *S. wallichii* mostly as antiseptic in wounds (Bhattacharjee et al. 2019). Lalrinzuali et al. (2015) have reported its uses to treat snake/insect bites and antiseptic properties of fruits and the bark powder is used to treat gastric problems.

Discussions

Wound healing is an intricate process continued with numerous cellular events. Hemostasis, inflammation, proliferation, and dermal remodeling are four distinct overlapping phases of wound healing. An important component of tissue healing and wound contraction is the rearrangement of ground collagen fibers, which can ultimately influence the quality of scars. The extracellular matrix functions as a reservoir for growth factors and signaling molecules and acts as a framework upon which endothelial cells can migrate during angiogenesis (DiPietro 1995; Li et al. 2003). The traditional healing system is unique, and these strategies are adopted by the rural tribals for sustenance and remedies for different ailments by using wild flora. Humans and plants share an age-old relationship. Dependence on plants is still seen and it is estimated that 25% of prescription drugs contain active components derived from higher plants (Tiwari and Joshi 1990; Das and Choudhury 2012). It has been estimated by WHO that at least 80% of the world population, mainly in developing countries, is still dependent on herbal medicines for their primary health care needs. The use of traditional medicine is based on its accessibility, affordability and its firm embedment within the people's faith systems (Kamboj 2000; Galabuzi et al. 2010). The tribal people living in rural areas cannot afford and do not have access to proper health care systems. Therefore, they largely depend on the indigenous knowledge of traditional medicines. Still today, the bioresources are so intrinsically interwoven with the lifestyle of tribals that medicinal plants are an inseparable part of the poor tribal communities (Zhasa et al. 2015). Depending upon the degree and types of illness, magico-religious ceremonies are organized along with ethnobotanical plants by the village priest or local medicine-man to heal and cure the dreaded diseases, including dermatological problems. Some information about the indigenous medicinal plants was gathered from the ethnic group within the local community through personal interaction. However, their recipes, compositions, drug preparation techniques, mode of use, and adding ingredients were different. Our present study particularly focused on wound healing and dermatological problems. We have selected plants that are abundantly available in our local region and plant species mostly used by ethnic groups to treat wounds, cuts, bruises, and skin diseases, including in our review article. The fascinating thing about medicinal plant species is that they have high phytochemical diversity, many of which possess interesting biological activities and medicinal properties, which is why they can cure and heal minor or different dreaded diseases.

Ethnic groups possess rich knowledge concerning diagnosing and treating significant to minor diseases and are typically specialists in the art of ancient medicine in their community. Indigenous traditional knowledge (ITK) is obtained through time for the local traditional healers. Most of those well-known possess substantive knowledge and principally practice for ages without scientific

knowledge and proper guidance but keeping in mind that ITK is passed on from one generation to another over time.

The information which was gathered from local ethnic groups was that it does not actually characterize particularly how precisely this interaction was initiated and convinced by the local traditional healer, but they interacted through personal communication by sharing their knowledge. Modern drugs are critical in treating and curing diseases; however, several tribal communities lack a physiological condition care system as their economies are engaged in subsistence agriculture. Moreover, they cannot afford the cost of modern medicines as ethnomedicinal practices are favored because they are more accessible, have low costs, are easy to prepare, and are eco-friendly. Knowledge of folk uses of medicinal plants opens up new avenues for the effective use of medicinal herbs in the future. Future work in this direction may help discover new drugs to treat wounds and dermatological problems though very little information about the scientific validation of the plant is still ongoing and limited. It should be our main aim to help propagate Indigenous Traditional Knowledge (ITK) developed by tribals to validate and treat various ailments related to humans and animals, the knowledge of these practices must reach the end-user for their benefit. Enormous clinical trials or clinical research are required to give positive evidence supporting the use of traditional medicine by creating awareness the benefit of using medicinal plants, and genuine good documentation should be encouraged.

In conclusion, the use of medicinal plants and their products to cure different ailments has been reported and documented, but still, confirmation and periodic clinical tests on the efficacy of these medicinal plants are yet to be scientifically validated or verified. However, combining traditional and modern knowledge can also produce better drugs/results for wound healing, dermatological complications and other diseases with fewer side effects. The local healers do not like to disclose, nor are they willing to share their traditional knowledge with others. It is because revealing their Indigenous Traditional Knowledge might affect their source of income and purposeless harvesting for their economic use may deplete these valuable plants. We should try to convince and explain the importance of useful plant species, which need to be conserved, and should be judicially utilized. Research reveals that there are numerous ways to improve the health care of the poor tribal based on the existing wealth gifted by Mother Nature and in fact, many medicinal plants are still yet to be explored. Valuable medicinal plants can undergo genuine analysis of herbal formulations and phytoconstituents of plants as it can open a new scope for researchers. The knowledge of various indigenous medicinal plants from village elderly and local healers can be of immense significance to herbal medicine researchers and the local population. Therefore, it is necessary to publicize these medicinal plants' recognition, utility and value. The treasure of Indigenous Traditional Knowledge may further be explored and validated clinically for effective use and acknowledging it is very important in motivating the local people, especially the rising generation, to carry this noble tradition for generations to come.

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