MEDICINAL PLANTS WITH ANTIBACTERIAL AND WOUND HEALING ACTIVITY: A REVIEW

Abstract

The rising prevalence of drug-resistant diseases necessitates the identification and isolation of novel bioactive components from medicinal plants utilizing standardized modern analytical methods. Understanding the molecular and cellular mechanisms that occur during normal wound healing has progressed significantly. Wound healing, whether accidental or surgical, necessitates the complex interactions of blood cells, soluble mediators, tissues, cytokines, and a plethora of growth factors. The fundamental goal of wound therapy is to either reduce the amount of time necessary for healing or to limit the negative outcomes. Because of the presence of various essential active phytoconstituents, plants have immense potential for wound management and therapy. Plants have a solid reputation in the field of wound treatment and repair due to their long history of use, low cost, and safety, but actual proof supporting their wound healing capabilities is lacking. Healing is a survival strategy that attempts to preserve normal anatomical structure and function. Through several mechanisms of action, phytochemicals are known to have potential antibacterial and wound-healing effects against susceptible and resistant microorganisms. Furthermore, various challenges and problems must be overcome in order to generate new antimicrobials and wound healing characteristics from plant extracts, while efforts have been undertaken to improve the antibacterial and wound healing activity of chemical compounds. In this review, we made an effort to shed light on the numerous plants that may be useful in therapeutic treatment because of their potential antibacterial and wound-healing properties.

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I. INTRODUCTION

There have been several reports of the therapeutic effects of natural products and plant products [1,2] made of active principles such alkaloids, flavonoids, and biomolecules [3]. Many plants utilized in traditional medicine are now included in the modern world's health care system. To date, more than 11,000 species of herbal plants are used medicinally, with roughly 500 of these commonly utilized in Asian and other countries [4,5]. WHO has long promoted traditional medicines as safe treatments for diseases of both microbial and non-microbial origin [6]. According to WHO, 80% of the world's developing nations still reap the benefits of using conventional medications made from medicinal plants [7,8,9].

The utilization of natural substances obtained from microbial, animal, or plant sources has caught the interest of many researchers despite the fact that synthetic anti-microbial medications have been approved in many nations [10,11]. These chemicals have shown promising benefits in combating antibiotic resistance in bacterial infections [12]. Plant-derived chemicals are a diverse class of chemical substances found naturally in plants. Based on their chemical compositions, they are divided into various primary classes, which include alkaloids, tannins, terpenoids, and polyphenols. The bioactive compound which promotes antibacterial and wound healing events can be therapeutically used to improve the antibacterial and wound healing activity.

Plants include a diverse range of phytochemicals that can be used to generate innovative drugs with specific biological effects [13]. Due to widespread, incorrect, irregular, and indiscriminate antibiotic use, antimicrobial resistance has developed, rendering many currently available medications ineffective [14,15,16]. As a result, there is a rising need for the development of innovative antimicrobial agents that can cut down on the use of antibiotics and stop the emergence of resistance. Researchers have been urged to isolate and identify novel bioactive chemicals from plants to tackle microbial resistance [17,18,19,20]. And, as current antimicrobials fail to treat infectious diseases, a lot of researchers have turned to natural products as a source of new bioactive compounds [21,22]. Furthermore, due to the ineffectiveness of some drugs, severe side effects, and the high cost of existing medications, there has been a growth in the use of medicinal plants as a treatment for human health in recent years, as well as a significant interest in pursuing therapies that are less aggressive to the human body [23].

II. ANTIBACTERIAL ACTIVITY

Long before civilization realized the existence of microbes, it was widely accepted that certain plants had healing properties, that they contained what we now call antibacterial principles. Plants have been utilized to cure common infectious diseases since antiquity, and some of these ancient remedies are still used in the routine treatment of diverse disorders [24]. Antimicrobial resistance is now a serious global issue. It occurs when bacterial, viral, fungal, and parasitic infectious organisms become resistant to conventional treatments, posing a risk to the public's health by dispersing infectious diseases and causing enormous global economic losses owing to food spoilage and crop damage [25,26]. Due to the wide variety of secondary metabolites and phytochemicals found in medicinal plants, researchers are becoming more and more interested in them as a means of combating antimicrobial resistance [27].

III. MEDICINAL PLANTS WITH ANTIBACTERIAL ACTIVITY

It has been demonstrated that extracts from medicinal plants have a range of biological effects, such as antibacterial, anti-inflammatory, and antioxidant capabilities 28. Antimicrobial chemicals derived from medicinal plants may prevent the growth of bacteria, fungus, viruses, and protozoa by different methods than those employed by antimicrobials already on the market. Additionally, they might be clinically beneficial for treating bacteria strains that are resistant to the present antimicrobials 29. Chemically complex molecules have high therapeutic promise since they have fewer adverse consequences than synthesized medications and have a low likelihood of developing resistance 30,31. Furthermore, the synergistic interaction of the extracts' active ingredients is what causes medicinal plant extracts to effectively prevent bacterial development 32. Medicinal plants contain a wide range of chemical components that have been shown in vitro to have antibacterial properties 33. Many investigations have shown that both natural and synthetic coumarin derivatives have antibacterial activity 34,35,36. Various scientifically evident plants used for management of antibacterial activity are given below:

1. **Acalypha indica Linn. (Euphorbiaceae):** A. indica L. is a common weed plant that has been used to cure pneumonia, asthma, rheumatism, and a variety of skin disorders. The presence of flavonoids, kaempferol, glycosides, mauritianin, ciltoria, and nictiflorin in A. indica leaves and flowers resulted in antioxidant activity. Raja et al. demonstrated the antibacterial activity of aqueous and acetone extract of plant leaves [37].

2. **Ageratina adenophora :** Manandhar et al. confirmed that the methanolic extracts of A. adenophora exhibited antibacterial activities against Escherichia coli, Staphylococcus aureus Salmonela Typhi, Citrobacter koseri and Klebsiella pneumoniae [38].

3. **Artemisia vulgaris:** Methanolic extracts of A. vulgaris exhibited antibacterial activities against the five tested microorganisms like S. aureus, K. pneumoniae, S. Typhi, E. coli and C. koseri. This was demonstrated in the study done by Manandhar et al. [38].

4. **Cinnamomum tamala:** The methanolic extracts of C. tamala was experimented for its antibacterial activities against K. pneumoniae, E. coli, S. Typhi, C. koseri and S. aureus. The findings demonstrated that the extract has antibacterial activity against all the microorganisms used in the study [38].

5. **Ferulago campestris :** Basile et al. [39] discovered that some pyranocoumarins and coumarins which is separated from the F. campestris roots shown substantial antibacterial action against both gram-positive and gram-negative bacteria. Aegelinol [40] and agasyllin [41] in particular were more active against ATCC strains of *E. aerogenes*, *S. aureu*s, *S. enterica* and *E. cloacae* (MIC = 32 µg/ml for agasyllin and 16 µg/ml for aegelinol).

6. **Hypericum olympicum :** The primary components of H. olympicum include spathulenol, farnesene and E-anethole with other components including terpenes, E-caryophyllene, germacrene D and a new form of acylphloroglucinol. The methanolic

extract of H. olympicum demonstrated a wide range of extremely potent antibacterial activity, with the maximum activity found against K. pneumoniae and S. enteritidis [42].

7. **Ocimum kilimandscharicum:** O. kilimandscharicum, an aromatic undershrub in the Laminaceae family with pubescent quadrangular branchlets is a traditional medicine used to treat a number of diseases such as cough, bronchitis, viral infections, anorexia, and wounds. According to Mahesh et al., it has proteins, flavonoids, tannins and other essential elements. In addition to having antibacterial and wound-healing capabilities, flavonoids also have antioxidant and free radical scavenging activities [43.]

8. **Oxalis corniculate:** The methanolic extracts of O. corniculate was studied for its antimicrobial activities against different microorganisms which include C. koseri, E. coli, S. Typhi, S. aureus and K. pneumoniae [38]. And the result indicates that the methanolic extracts of O. corniculate exhibit antimicrobial activities in all the tested microorganisms.

9. **Punica granatum:** Due to its versatility and nutritional advantages in the human diet, P. granatum (pomegranate) consumption has increased. In particular, it is high in bioactive chemicals that belong to the phenolic compound family, like anthocyanins and tannins. Alexandre et al. [44] observed that the antioxidant activity and phenolic component concentration were shown to be highly associated to antimicrobial activity in a study of antimicrobial action on pomegranate peel extracts. As a result, high-pressure pomegranate peel extracts could be used to generate high-value bioactive compounds for antioxidant as well as antibacterial applications. Additionally, Mostafa et al. [45] examined the potential antibacterial activity of ethanolic extracts of P. granatum and discovered that it is variable in its efficacy against the tested bacterial strains.

10. **Syzygium aromaticum:** For its antibacterial action, an ethanolic extract of S. aromaticum proved possibly beneficial with varying effectiveness against the examined bacterial strains. In the experiment conducted by Pundir et al. [46] the ethanolic extracts of S. aromaticum inhibited the development of all the examined food-associated bacteria, with the diameter of the zone of inhibition ranging from 25 to 32 mm. Its zone of inhibition diameter against E. coli was the biggest, measuring 32 mm, and it was followed by S. aureus (31 mm) and B. subtilis (30 mm). Against B. megaterium and B. sphaericus, the S. aromaticum ethanolic extract exhibited a zone of inhibition with a similar diameter of 28 mm. The ethanolic extract of S. aromaticum has also been found by Sulieman et al. [47] to be antibacterial against E. coli, S. aureus and B. subtilis, having the highest antibacterial activity against E. coli. Eugenol (2 methoxy-4 allyl-phenol) is connected to the antibacterial properties of S. aromaticum [48]. It has additional antibacterial qualities due to the high tannin content (10-19%) [49].

11. **Thymus vulgaris:** At a dosage of 10 mg/ml, Mostafa et al. [45] studied the antibacterial activity of T. vulgaris, which was possibly effective with varying efficiency against the investigated bacterial strains.

12. **Ziziphus nummularia:** Z. nummularia contains a high concentration of phytochemical substances, mainly cyclopeptide alkaloids. In one of the early studies, nummularine-N

and nummularine-M, two new cyclopeptide alkaloids, as well as the presence of several other cyclopeptide alkaloids in the plant's root bark, were discovered in 1983 [50]. Cyclopeptide alkaloids are natural macrocyclic molecules with intriguing biological and chemical properties that are abundant in the family Rhamnaceae, particularly in the Ziziphus genus [51,52]. Beg et al. used several extraction solvents to assess the antibacterial activity of Z. nummularia extracts from leaves, bark and fruits against the gram-positive bacterium S. aureus and the gram-negative strain E. coli. [53]. The outcomes demonstrated that the methanolic extract of the fruits had the highest bacterial resistance against the two strains, followed by hexane and chloroform extracts, the aqueous extract of all plant parts exhibited no antimicrobial activity [53]. Interestingly, the fruit of the plant was shown to have significant antibacterial action against the gram-positive strains examined [54].

Another research found that the ethyl acetate and chloroform fractions of Z. nummularia were efficient against the two gram-positive and bacteria gram-negative, however, the methanolic and aqueous fractions had no activity against any of the microorganisms examined [55]. According to Gautam et al. the ethanolic extract of Z. nummularia was more effective than the aqueous extract at killing S. aureus and P. aeruginosa while having no effect on B. subtilis [56]. Sharma et al. ascribed Z. nummularia's antibacterial activity to the presence of flavonoids, glycosides, saponins and alkaloids in the plant's leaf extracts, indicating that leaf extracts could be a viable treatment for a variety of ailments [57].

These potentially useful plant extracts could be employed as natural substitutes to chemically-based antibacterial treatments to prevent food poisoning and preserve food without posing any health risks.

IV. WOUND HEALING

A physical injury that causes an opening or breach in the skin's barrier function and normal architecture are called wound. They result in the loss of epithelial continuity, whether or not underlying connective tissue is also lost [58.] Following an injury, the skin has an amazing ability to regenerate itself. Several processes are involved in the intricate (yet orderly) phenomenon of healing a wound, including the initiation of an acute inflammatory response by the wound, the regenerative process of parenchymal cells, the migration as well as proliferation of both parenchymal and connective tissue cells, the production of extracellular matrix proteins, the remodelling of connective tissues and the development of wound strength. Any modifications to any of these procedures may result in a delay in healing or even complete healing failure [59.]

According to current estimates, approximately 6 million people worldwide are affected by chronic wounds [60]. Wound epidemiology research is extremely limited. In order to aid in wound healing, medical therapy for wounds involves injecting medications either locally (topically), systemically (oral or parenterally), or both [61]. Antiseptics, antibiotics and disinfectants and have a broad spectrum of non-selective antibacterial effect when administered topically [62]. Topical antibiotics has been frequently used in clinical settings in cuts, wounds and burns to treat localized skin infections. However, overuse of topical antibiotics can result in consequences such as the development of resistant organisms [63]. As a result, efforts should be aimed toward developing an agent that can expedite wound healing when it is normal or when it is hindered by various agents such as corticosteroids, anti-neoplastic, or non-steroidal anti-inflammatory drugs [64].

A variety of cell strains and their by-products work together to repair cuts on the skin, which is an essential physiological activity [65]. This literature review's objective is to draw attention to the biological mechanisms at work during the healing of wounds, with a focus on the cells, growth factors, and cytokines involved in the process of tissue repair.

Stages of wound healing

1. **Inflammatory Stage:** During a vascular inflammatory reaction, the lesioned blood arteries compress and the blood that is discharged coagulates, maintaining the vessel's structural integrity. The activation and accumulation of thrombocytes and platelets into a fibrin network is known as coagulation, and it depends on the impact of specific stimuli on these cells [66]. By releasing lysosomal enzymes and reactive oxygen species and enabling the elimination of various cell detritus, inflammatory cells promote the healing of wounds [67].

2. **Proliferative stage:** The proliferative stage’s goal is to minimize the lesioned muscle area by contracting and fibroplasia, thereby generating a strong epithelial barrier which will stimulate keratinocytes. This stage is in charge of the lesion's closure, which involves angiogenesis, fibroplasia, and reepithelialisation. These processes begin in the lesion's microenvironment within the first 48 hours of the lesion's formation and can last for up to 14 days [68]. Granulation tissue appears four days after the wound and starts to expand. Its name is derived from the characteristic of the forming stroma, which is granular appearance of newly produced tissue. In accordance with Calin *et al.* [69] increased fibroblast proliferation, collagenous and elastic biosynthesis, which forms a three-dimensional extracellular network of connective tissue, and fibroblast production of chemotactic factors and IFN-beta are all necessary for the development of granulation tissue. The process of wound contraction, which is carried out at this stage by myofibroblasts, which are abundant in alpha smooth muscle actin, was found by Medrado *et al.* [67].

3. **Remodelling stage:** The third stage of healing, known as remodelling, begins two or three weeks after the lesion first appears and lasts for an entire year or more. Maximizing tensile strength through extracellular matrix reconfiguration, breakdown, and resynthesis is the main objective of the remodelling stage. The granulation tissue is gradually transformed during this last stage of lesion's recovery in an effort to bring back the native tissue structure, leading to scar tissue that is gradually becoming less cellular and vascular [70] and has a higher concentration of collagen fibres.

V. MEDICINAL PLANTS WITH WOUND HEALING POTENTIAL

Traditional medicine has been called as an alternative medicine, non-conventional medicine, phyto-medicine, complementary medicine, herbal medicine, natural medicine, indigenous medicine, ethno medicine, folk medicine etc [71]. According to estimates, 70% of Ayurvedic medicines used to treat wounds are made from plants, 20% from minerals, and the other 10% are animal-based [72]. The following are the scientifically proven plants used for wound healing management:

1. **Acalypha indica Linn. (Euphorbiaceae):** A. indica L. a weed plant, has been used to treat a number of skin disorders as well as pneumonia, asthma, and rheumatism. The presence of flavonoids, kaempferol, glycosides, mauritianin, ciltoria, and nictiflorin in A. indica leaves and flowers resulted in antioxidant activity. A. indica dried leaf ethanolic extract has been used to heal wounds and bedsores [73,74].

2. **Ageratum conyzoides:** A. conyzoides, a member of the Asteraceae family, is a prevalent weed known as goat weed and white weed. According to Chah et al.'s research, when the leaves are put to wounds, they function as an antiseptic and heal the wounds [75].

3. **Aloe vera Linn. (Liliaceae):** Davis investigated the wound healing property of A. vera. One of the oldest medicinal plants in the world is A. vera Linn. (Liliaceae). It is applied topically to treat wounds, burns, insect bites, bruises, welts, skin lesions, eczema, and sunburns. When mice were given 100 mg/kg/day of A. vera orally, and when they were given 25% aloe vera topically, the size of the wound was reduced by 62.5% and 50.80%, respectively. These results suggest that A. vera aids in the healing of wounds. The amino acids and vitamins C and E found in A. vera leaves are essential for wound healing [76].

4. **Anthocephalus cadamba Roxb. (Rubiaceae):** The primary components of the bark of A. cadamba Roxb. (Rubiaceae) are saponins, triterpenes, and the indole alkaloids cadambine, 3adihydrocadambine, cadamine, isodihydrocadambine and isocadamine. Umachigi et al. investigated wound healing activity and discovered that when hydro-alcoholic A. cadamba ointment was applied, the epithelization period was reduced, as was the scar area. Both the hydroxyproline content and the tensile strength increased significantly. The unprocessed hydro-alcoholic extract encouraged wound contraction substantially. As a result, the plant extract may be effective as a wound healing agent [77].

5. **Argemone mexicana Linn.:** Employing excision and incision wound models, various A. mexicana L. (Family: Papaveraceae) leaf extracts were examined for their capacity to accelerate the healing of wounds in rats. The wound closure rate, epithelialization period, strength of skin breaking, the granulation tissue weight, hydroxyproline determination, superoxide dismutase, catalase, and tissues granulations' histology were used to assess the effects of test samples on the rate of healing of wound. For the activity comparison, Nitrofurazone (0.2% w/w) in Simple ointment I. P. was utilized as the standard. The study's findings showed that rats inoculated with methanolic and aqueous extracts of A. mexicana healed more rapidly than those treated with other extracts. The chloroform extracts of the selected plants yielded encouraging results as well, but to a lower extent than the comparable methanolic and aqueous extracts. The petroleum ether extract yielded no noteworthy findings. The ability of the extract to heal wounds may be credited to the existence of phytoconstituents in chloroform, methanol, and aqueous extracts, such

as tannins, alkaloids, flavonoids and triterpenoids which have been shown to aid healing of wound due to their antimicrobial, antioxidant and astringent properties. The current study supports the use of A. mexicana leaves for wound healing, as reported in folkloric research [78].

6. **Arnebia densiflora:** A. densiflora roots steeped in butter were previously used to treat minor wounds. This plant's roots have been shown to contain alkannin derivatives such as methyl-n-butylalkannin, dimethylacrylalkannin, teracrylalkannin and isovalerylalkannin. According to Kosger et al. rats given A. densiflora healed faster compared to the control group. On the 14th day after the damage, the wound's closure and collagen formation accelerated and healing took place [79].

7. **Carica papaya Linn.:** C. papaya L. is a member of the Caricaceae family. Azarkan et al. discovered that papaya fruit includes a combination of cysteine endopeptidases like papain. Papaya contains chympopapain A and B, omega endopeptidase, chitinase, protease inhibitors, and proteins. It also contains papaya endopeptidases II and IV. Given that papaya fruits have the ability to cure wounds, papaya latex was administered to the burn wound using hydrogel as a carrier method [80].

8. **Centella asiatica (Linn.) Urban (Apiaceae):** C. asiatica is also known as Asiatic Pennywort is a herbaceous, perennial herb in the Apiaceae family [81]. Saponins containing triterpens, such as madecassic acid, asiatic acid, madecassoside and asiaticoside have been shown to be the most active therapeutic biomarker molecules in plants [82]. A cream containing 1% C. asiatica extract has been shown to promote chronic wound healing [83]. Shukla et al. examined the topical application of asiaticoside's wound-healing properties in mice with normal and diabetic blood sugar levels. The pace of wound healing in normal animals was noticeably speeded up due to an increase in collagen synthesis and wound tissue tensile strength [84].

   Liu explored the impact of madecassoside on wound healing through a variety of mechanisms such as antioxidative activity, angiogenesis and collagen synthesis [85].

9. **Curcuma longa Linn.:** C. longa L. which belongs to the family Zingiberaceae, has been said to exhibits anti-inflammatory, antibacterial and antifungal activities in the study by Rao. It uses rhizomes and includes 1,7-bis, 6-hepta-diene-3, 5-dione, turmerol, and curumin (diferuloyl methane). Analgesic and anti-inflammatory effects are present in curcumin. C. longa volatile oil has antibacterial and anti-inflammatory properties as well. C. longa also includes protein, lipids, and vitamins (A, B, C and so on), which all aid in the regeneration and healing of wounds. C. longa has been used to treat wounds in rats [86].

10. **Euphorbia nerrifolia Linn. (Euphorbiaceae):** E. neriifolia L. flourishes in north, central, and southern India [87]. Bigonia et al. investigated the E. neriifolia leaf's capacity to heal wounds in an excision and dead space wound model. Contraction of wounds and epithelialization were enhanced by E. neriifolia's elevated protein and hydroxyproline content [88]. Gour et al. also investigated the analgesic and anti-inflammatory properties of plant hydroalcoholic leaf extract and discover positive results [89].

11. **Ficus racemosa Linn. (Moraceae):** F. racemosa L. is a huge deciduous tree scattered all over India specifically in northern India [90]. Murti et al. investigated the wound healing activities of ethanolic as well as aqueous extract of F. racemosa roots using incision as well as excision model of wound. Aqueous root extract promoted epithelialization and collagen synthesis, which raised the percentage of wound closure rate [91].

12. **Helianthus annus Linn.:** An ornamental annual herb from the Asteraceae family, H. annus L. is typically found in swampy places and has an upright, rough, and hairy stem. Tribals utilize the herb in traditional medicine to treat colic, eye inflammation, dysuria, sores, bone fractures and tiger bites. Deshpande et al. found that using an alcoholic extract of H. annus as an ointment to a rat's excised lesion resulted in a considerable reduction in total healing time. Histology verified this, as early fibroblast appearances were observed. Early emergence and increased build-up of mucopolysaccharides have been identified as indications of accelerated [92].

13. **Hygrophila auriculata:** Dev & Roy [93] used an excision wound model to investigate the potential of wound healing of the H. auriculata root in Swiss albino mice. The animals in the study were separated into three groups of six (3 males and 3 females) apiece. Carboxymethyl cellulose (control) was applied topically to animals in group 1. Group 2 mice were given a reference medication (a positive control). Animals in Group 3 were given a root extract of H. auriculata. The evaluation of healing was done by measuring the area of wound, histomorphological findings and calculation of the content of both DNA and protein. The findings revealed that the extract-treated group's wound area was less than that of the control group. In comparison with the control group, epithelialization was quicker in the treated group. DNA and protein levels were also higher in experimented mice than in control mice. The level of recovery in the experimented animals was equivalent to the positive control group. As a result, the findings indicate that the root of H. auriculata has the capability to heal wounds.

14. **Kigelia pinnata:** K. pinnata, a member of the Bignoniaceae family, is a tiny tree found in the Southern, Central and Western Africa, as well as India. According to Sharma et al. the bark has been pharmacologically established to have wound healing properties as well as antibacterial, antifungal, antiamoebic, antiulcer and antioxidant activity [94].

15. **Lantana camara Linn. (Verbanaceae):** L. camara L. (Verbanaceae), a shrub native to tropical America, has become entirely naturalized as an ornamental plant in many parts of India. According to Kurian's research, the herb contains wound healing qualities along with abortifacient, antimalarial and anti-inflammatory. Wound contraction has been aided by hydro-alcoholic extract and fresh juice of leaves [95].

16. **Lawsonia inermis Linn. (Lythraceae):** The leaves of L. inermis L. (Lythraceae), sometimes known as henna, are used in the treatment of burns, skin inflammations, wounds, and ulcers as a decoction or ointment. The leaves have antifungal and antibacterial properties as well. Henna is said to contain the natural colour naphthaquinone, lawsone. Lawsone combined with an ethanolic extract of henna leaves produced a considerable healing response in both wound models, according to research by Sakarkar et al. Furthermore, it was discovered that topical application of ethanolic

extract as well as separated lawsone was more efficacious than oral administration. Thus, application of ethanolic extract to the skin for wound healing can be successfully developed [96].

17. **Morinda citrifolia :** In the study by Nayak, animals treated with M. citrifolia extract showed a considerable improvement in wound-healing activity when compared to those given placebo control treatments. When compared to control rats given normal water, the extract-treated animals demonstrated a faster decrease in the size of wound and a shorter period of epithelialisation [86].

18. **Napoleona imperialis:** N. imperialis belonging to the plant family Lecythidaceae is a tall, woody shrub found primarily in tropical rain forests. The leaf is employed as an analgesic, tonic, antitussive, anti-asthmatic, and wound dressing on a local level. The numerous ointments made with N. imperialis displayed a successful wound healing effect in the study by Esimone et al. a standard antibiotic employed in healing of wound [97].

19. **Ocimum sanctum Linn. (Labiaceae):** O. sanctum L. sometimes referred to as 'Tulsi' is extensively grown herb in India and other areas of the world. It has antibacterial, analgesic, immunostimulatory, anti-inflammatory, and free radical scavenging effects. Plant flavonoids' free radical scavenging action aids in wound healing. The topical wound healing properties of O. sanctum aqueous extract were examined by Asha et al. [98]. Goel et al. used an excision wound model in wistar albino rats to investigate the wound healing activities of a cold O. sanctum aqueous extract as well as its impact on tumour necrosis factor- (TNF-). Wound healing was observed to occur more quickly in rats treated with O. sanctum extract in comparison with the control group as a result of enhanced TNF-production [99].

20. **Resina draconis:** Huihui et al. [100] used the model of excision as well as incision wound in rats to investigate the wound healing potential of R. draconis (Dracaena cochinchinensis). In addition to histological exams, the expression of VEGF and TGF-1 and the percentage of wound contraction were all recorded. The study offers a rationale based on science for R. draconis conventional application in wound treatment.

21. **Rubia cordifolia Linn:** Karodi et al. [101] investigated the ability of R. cordifolia L. (Indian madder) extract to treat mice's wounds. The ethanolic extract as well as its hydrogel were assessed for their healing effectiveness on an excision wound model in mice, and the work provides a scientific explanation for the folkloric usage of this plant in wound handling. More et al. and Umachigi et al. also investigated the existence of tannins, phytosterols, anthraquinone glycosides and saponins in an ethanol extract of R. cordifolia. Tannins as well as anthraquinones are the primary phyto-constituents found in this plant, and they might be in charge for the healing of wound [102,77].

22. **Tectona grandis Linn.:** T. grandis L. belongs to the Verabinaceae family and comprises primarily tannins, carbohydrates and anthraquinone glycosides. It is applied topically to treat burns and as an anti-inflammatory medication. It is primarily used to treat burns,

inflicted wounds, and skin ulcers. According to Majumdar et al. T. grandis L. extract improved breaking strength, wound contraction, and collagenation when used topically or internally [103].

23. **Terminalia superba:** Dougnon et al. [104] investigated the wound healing as well as antibacterial effects of T. superba bark ethanol extract. The ethanol extract's antibacterial activity and in vivo wound healing characteristics on lesions infected by reference strains of E. coli ATCC 25922 and S. aureus ATCC 25923 in wistar albino rats were also examined. T. superba's antibacterial qualities contribute to the development of a better traditional medicine.

24. **Tridax procumbens Linn. (Asteraceae):** T. procumbens L. (Asteraceae) is a tropical American native that has spread to tropical Africa, Australia and Asia particularly India. According to Diwan et al. the leaf of T. procumbens includes primarily crude protein, crude fibre (17%), soluble carbohydrate (39%), and calcium oxide (5%). Villagers use the juice of this plant's leaves to stop bleeding from animal cuts and bruises. This juice has the ability to accelerate two stages of healing: epithelialization and collagenization, while delaying scarring and granulation [105].

25. **Wedelia chinensis:** W. chinensis Merrill (Syn. Wedelia calendulaceae) (Asteraceae) is a renowned herbal remedy in both the Ayurvedic as well as Unani systems of medicine. Verma et al. [106] studied the efficiency of healing of wound in W. chinensis ethanolic leaf extract using the models of excision, incision and dead space wound. When compared to control treatments, mice treated with W. chinensis extract shown a substantial increase in wound-healing activity. The property of healing of wound in W. chinensis' might be related to the phytochemicals in the plant, and the rapid process of wound healing might be a product of either the individual or additive actions of the phytoconstituents.

VI. CONCLUSIONS

In conclusion, we believe that studying medicinal plants as antibacterial and wound healing agents is crucial for understanding medicinal flora and their true worth, but that using a standard technique of analysis is essential. Similarly, the concentrations or dilutions utilized must be suitable. There is a lot of evidence that medicinal plants are particularly efficient in treating infectious diseases because they are necessary for human survival. The plants have a lot of potential as a source of new antibacterial compounds. They are widely available, inexpensive, and nearly without side effects. Plant derivative substances, including phytochemicals, have even been used to treat a variety of disorders, exhibiting intriguing antibacterial activity and wound healing against a variety of human pathogens. A number of these chemicals have both antibacterial action and the ability to change antibiotic resistance. While some of them are inefficient as antibiotics on their own, they can combat bacterial antibiotic resistance when used in combination with other antibiotics. Finally, because of their qualities, people have been more interested in herbal-based medications in recent years. To assure the safety of the extracts, numerous investigations on their methods of action, interactions with antibiotics or other medicinal plants or compounds, and their pharmacokinetic profile should be prioritized.

VII. FUTURE DIRECTIONS

Combining conventional and modern knowledge can result in more efficient antibacterial and wound healing agents with less negative effects. The major challenge in the creation of novel phytochemicals has been the conversion of *in vitro* investigations to *in vivo* experiments, and then to human clinical trials. Natural antimicrobial drugs present a particular challenge since a variety of parameters, such as tissue penetration, maximum attainable plasma concentration, and bioavailability, might affect their activity. However, more investigation is required to have a better knowledge of the precise mechanisms as well as the pharmacological and pharmacokinetic attributes of the compounds.

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