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Review

A Review of Moringa Oleifera for Wound Healing

Vigneshwaran. L V, Kathirvel. B*, Abinayah. S, Sivashankar. B, Jeeva. S, Vasanth. S, Jagatheeswaran. M

RKP College of Pharmacy, Krishnagiri Tamilnadu, India.

*Author for Correspondence: Prof. Kathirvel.B
Email: kathirvel9443@gmail.com

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Abstract

The natural process of wound healing restores injured tissues that have lost their integrity. in malaysia, moringa oleifera, sometimes referred as merunggai, has long been used to treat a variety of illnesses, including wounds. The leaves of moringa oleifera are a great source of fibers, minerals, anti-inflammatory, antidiabetic, and antimicrobial properties are all possible with this extract. CENTRAL, pubmed, Google scholar, Science Direct, LILACS, and ClinicalTrails.gov are among the databases that were the subject of 18 in vitro investigations in all; the othr 5 studies examined various plant components in models of excision, incision, desd sopace, abrasion, and burn-included wounds. Significant wound healing powers were demonstrated in all investigations. The majority of research employed various topical formulations of aqueous leaf extract. The analysis of research data was assessed using the ANOVA statistical test. The aims, research design, and results of the listed studies were used to examine the data. there were 1,375 records found in databases,1344 records thet were screened, 25 reports that were searched for retrivel ,17 reports that wee evaluated for elibiblity, and 9 fulltext articles in yhe systematic review. critical findings that had been carefully chosen to satisfy the research inclusion criteria were the basis for nine papers' eligibility. This paper a thorough overview of the plant's pharmacological and phytochemical properties as well as its traditional and medicinal applications. M.oleifera is used pharmacologically and traditionally foe a wide range of pathophysiology disorders. we will go over the many characteristics of the drumstick tree, M.oleifera, with an emphasis on its seversl therspuetics uses . To give patients with acute and chronic wounds receiving at-home or hospital treatment more information, research involving a comprehensive review of the efficacy of moringa oleifers leaves for wound healing is crucial. M. oleifera shown the ability to cure wounds, however more research is necessary to identify the primary bioactive phytochemical and safety.

Keywords: Moringa oleifera, Anti inflammation, Anti-oxidant, Anti-microbial.

INTRODUCTION

Repairing damaged tissues is a natural part of wound healing. The four overloping phases that it goes through are tissue remodeling, inflammation, proliferation, and hemostasis (blood clotting). Numerous cell types, including keratinocytes, fibroblasts, inflammatory cells, and endothelial cells, are involved in these intricate processes. Humans from all over the world have been healing wounds in different ways for ages, but modern wound healing techniques only emerged in the 20th century [1].

Protein, minerals, and fiber are abundant in moringa leaves (Riaz&Wahab,2021). A powerful herbal medicine full of advantageous ingredients is moringa oleifera leaf extract (MOL)(Ningrum et al.,2023). According to Gopalkrishnan et al. (2016), this extract has antibacterial, anticancer, anti-inflammatory, and antidiabetic properties. One of the recommended extracts for the antioxidant movement of M.oleifera is methanolic leaf extract, which may be used to treat a few illnesses(sayyed et al.,2019) [2].

In order to ensure tissue restoration, wound healing is a dynamic and intricate process that involves sequence of process. An ordered sequences of process makes up wound healing. To restore the integrity of the injured tissue, some of them take place right away, others a few days later, and some later. Changes in any of these phases can cause a delay in healing or even the inability to heal wounds. The inflammation stages starts as soon as an injury occurs, with vasoconstriction that promotes homeostatis first, followed by vasodilation that releases inflammation medicators[7].

New therapuetic approaches and technology are constantly being developed to lesson the financal and healthcare burden of wounds. Simultaneously, research is being done to asses the effectiveness of established traditional wound-healing techinques, including using herbs, or other uncoventional ways, like leech therapy. Non-toxic and reasonably priced wound derssing are great[4].

The leaf is most frequently used of the part of the plant for therapuetic purposes.The primary phytochemical compounds isolated from the leaves of moringa oleifera encompass glycosiates,flavonoids,and phenolic acids ,which offer protection against (chronic disease such as hypertension, diabetes, cancer, metabolic disorder, and general inflammation). The research conducted of moringa oleifera leaf extracts in diabetic conditions and investigate its potential to enchance wound healing in patients [2].

PHYTOCHEMISTRY

Its primary constituents include carotenoids, tocopherols (α, γ, and δ), flavonoids, phenolic acids, folate, and other minerals. 35 compounds were found in the plant's leaf according to gas chromatography-mass spectrometry analysis; significant compounds that were isolated included palmitoyl chloride, beta-1-rhamnofuranoside, n-hexadecanoic acid, tetradeconic acid, 50acetylthio-octyl, gamma-sitosterol, and pergna-7-diene-3-ol-20-one.It was discovered that the most prevalent carotenoid in leaves was e-lutein. The plant's radicle contains benzoylglucosinolate and 4-(α-l-rhamnopyranosyloxy)-benzylglucosinolate. Roots include spriochin and anthonine, which have antibaterial properties.The plant's peduncle contains beta-sitosterone, octacosanoic acid, vanillin, 4-hydroxymellein, and β-sitosterol.

Octacosanoic acid, 4-hydroxymellein, β-sitosteral, and alkaloids (moringine and moringinine) are all found in its stem. Exudates from entire gums contain L-rhamnose, D-glucuronic acid, Iarabinose, D-mannose, D-xylose, and D-galactose.Leucodelphindin is another significant ingredient in gum. 3-O-B-D-galactopuranosy-O-B-Dglucopyranoside.

PHARMACOLOGICAL ACTIONS

Almost all of the ingredients in this "miracle tree" have been demonstrated to have analgesic effects in a number of animal models. In both central (hot plate method) and peripheral (acetic acidinduced writing method) models, extracts of leaves, seeds, and bark demonstrated significant analgesic activity in a dose-dependent manner. Leaf extracts also demonstrated dosedependent antimigranine properties and analgesic potency comparable to indomethacin. Topical treatment was effective in reducing neuropathic pain brought on by multiple sclerosis

In a model of paw edema caused by carrageenan, leaf extract has been shown to have antiinflammatory properties. In the same model, bark extracts exhibited anti-inflammatory properties similar to those of diclofenac. There have also been reports of the root's antiinflammatory qualities. The control of neutrophils and the c-Jun N-terminal kinase pathway may be the mechanism underlying the anti-inflammatory action. The active ingredients that support the anti-inflammatory action include tannins, phenols, alkaloids, flavonoids, carotenoids, βsitosterol, vanillin, hydroxymellein, moringine, moringinine, β-sitostenone, and 9-octadecenoic acid.

WOUND HEALING ACTIVITY

Extracts of leaves, dried pulp, and seeds showed a significant reduction in scar area and skinbreaking strength in incision, excision, and dead space wound models, while increasing hydroxyproline content, wound-

closure rate, granuloma-breaking strength, and granuloma dry weight [3]. 36 healthy Wistar rats weighing between 150 and 200 g participated in the experiment using procedures described in the literature[10].

Research on the effects of leaf extract on wound healing in diabetic animals revealed notable antiproliferative and anti-migratory effects on normal human dermal fibroblasts, as well as decreased wound size, increased vascular endothelial growth factor, decreased inflammatory mediators, and improved tissue regeneration in wound tissues.For a week, the Wistar rats were given conventional rat pellets and unlimited water to help them get used to their new surroundings.

The rats were assembled into six groups, A, B, C, D, E, and F. Each group contained six rats, who were kept in separate plastic cage compartments. The rats used in this study were handled in accordance with the NIH's care guidelines for rodents and laboratory animals [10].

According to 39% of the research examined, the plant was validated without a deposition. Reference number, whereas 28% went through an authentication procedure that used the plant's voucher specimen deposition. None of the 18 studies qualitatively recognized the phytochemicals associated with M. oleifera, nor did they quantitatively ascertain the phytochemicals' composition. Molecules only reported two tests using a standardized formulation of M. oleifera, but the data are sparse. Comprehensive information on the qualitative and quantitative phytochemical analysis and the herbal supplement's standardized formula can be found in the Supplementary Material.

Interventions from every experiment that was included [1].

METHODS

Plant and aqueous extract preparation

California Gold Nutrition was the source of the Moringa oleifera leaves. The plant material was ground into a fine powder through processing. Using distilled water, the 200 g of powder was extracted by maceration with constant stirring for 24 hours. After filtering, the extract was lyophilized. Before being used, the dried aqueous extract was kept at 4°C [7]. The chemical laboratory of Universitas Diponegoro's Faculty of Mathematics and Natural Sciences provided the Moringa oleifera leaf extract. Moringa oleifera was the substance utilized. After being gathered and sorted moist, the leaves of Moringa oleifera were cleaned by running water and separated from the stems [11].

We searched the ScienceDirect, Google Scholar, Semantic Scholar, and PubMed databases. "Moringa oleifera," "Moringa oleifera leaves," "Moringa oleifera seeds," "Moringa oleifera bark," "wound healing," "abnormal wound healing," and "chronic wound" were among the search terms we used [12]. After being cleansed, Moringa oleifera leaves are dried in a cabinet drier set to a maximum temperature of 400C. Moringa oleifera is sorted dry and shrunk in size after drying. After being macerated with a 96% ethanol solvent, simplicia leaves were filtered. Following filtering, a rotary evaporator was used to evaporate the resulting ethanol extract, which was subsequently weighed. The thick extract produced was mixed with pure vaseline to obtain 10% Moringa oleifera [11].

ANTICANCER ACTIVITY

In research using mouse melanoma tumor models, alcoholic and hydromethanolic extracts of leaves and fruits shown a notable growth delay in tumor kinetics. Extract of leaf also exhibited antiproliferative activity on A549 lung cells. In vitro, a root and leaf extract demonstrated cytotoxic activity against cisplatin-resistant ovarian cancer cells as well as colorectal, hepatocarcinoma, and breast cancer cells.While leaf extract shown strong antitumor and hepatoprotective properties, flower extract promoted cell proliferation in healthy cells but not in cancer cells. These results point to MO's potential for regeneration in addition to its anticancer activities [3].

ANTIDIABETIC ACTIVITY

The leaf extract showed significant hypoglycemic and anti-hyperglycemic effects in both normal and alloxan-induced diabetics. Aqueous leaf extract's effects on insulin-resistant individuals' lipid profiles, body weight, glucose, plasma insulin, homeostatic model assessment, and oral glucose tolerance test.

ANTIBACTERIAL ACTIVITY

The agar diffusion method was used to determine the nanofibers' (A—E) antibacterial sensitivity to S. aureus and E. coli. The bacterial species were selected because they were pertinent to wound infections. The plates were kept at 37 °C for 24 hours while being watched carefully for the formation of clear zones surrounding the nanofibers. The diameter of the zone of inhibition, measured in millimeters, was used to assess the antibacterial sensitivity. A positive control of 1 mg/mL streptomycin was utilized in the two repetitions of the experiment. The statistical program SPSS 21.0 was used to analyze the antibacterial data of the two-run experiment. The antimicrobial investigation was carried out using the procedures documented in the literature[10].

HISTOPATHOLOGOCAL STUDY

Skin wound samples from both treated and untreated were collected. To enable the fixative solutions to function quickly and uniformly, the fresh tissue was cut into 5 mm thick pieces and rinsed under running water. After being fixed for a maximum of 48 hours in 10% buffered formaldehyde, the samples were processed for 18 hours in an automated tissue processor with Leica TP 1020 apparatus [7]. The study's were put to death on the eleventh day while under ether anesthesia. The specimens from the wound area were preserved and stored using 10% buffered formalin. Hematoxylin-eosin was used to mark 5 µm slices to show the architecture of the skin, and Masson trichrome was utilized to show the collagen fibers. The Leica DM750 microscope, which has a digital camera attached, was used to examine these sections. The tissue sections were digitally photomicrographed at a magnification [10].

ANTI-ALLERGIC ACTIVITY

In an Ovalbumin sensitization model, seed ethanolic extract reduced the frequency of scratching and inhibited passive cutaneous anaphylaxis caused by mast cell histamine release and antiimmunoglobulin G (IgG) antibody; the mechanism behind these effects may be membrane stabilizing activity [3].

ANTIMICROBIAL ACTIVITY

The leaf's ethanolic extract exhibited antibacterial efficacy against every tested bacterium. According to reports, chloroform extract has antimicrobial properties against Salmonella typhi, Pseudomonas aeruginosa, Escherichia coli, and Vibrio cholerae.

Ethanolic extracts from roots and bark have demonstrated antifungal action against Aspergillus niger, Neurospora crassa, Rhizopus stolonifer, and Microsporum gypseum, as well as an inhibitory effect against Leishmania donovani. Several studies suggest that seed extracts could be a good option for purifying water sources since they inhibited bacterial growth in agar and nutrient media. A methanolic leaf extract inhibited urinary tract infections like E. coli, S. saprophyticus, Klebsiella pneumoniae, and Staphylococcus aureus. [3]

DISCUSSIONS

Wound healing is a survival strategy that maintains the normal anatomical structure and function of living tissue after it has been disrupted by physical, chemical, microbiological, or immunological injury. Moringa oleifera leaves are a great source of active ingredients for health products since they are packed with bioactive compounds like vitamins, minerals, and phytochemicals [2].Our research revealed that the herbal plant M. oleifera, which has long been used in India as a leaf paste for wound healing, had beneficial effects on the healing process when applied topically or taken orally [1].

In order to examine the impact of a phytotherapeutic on healing, the current experimental model of cicatrization of skin wounds was carried out following streptozotocin-induced diabetes. We examined how the lesion area changed over time and discovered that, up until the tenth day, the Moringa oleifera extract had a beneficial effect on minimizing the wound area in comparison to the controls, who received standard saline treatment. We have hypothesized that a number of factors contributed to this positive outcome [7]. The process of wound healing is crucial for repairing damaged tissue continuity and restoring the skin's natural function. The four overlapping phases of wound healing inflammation, coagulation, migration, and remodelling involve constant interactions between bodily cells [10]. In order to promote fibroblast cell infiltration and hasten the production of growth factors for wound healing, the proper moisture content or humidity in the wound area is also crucial. Three processes fibroblast development, keratinocyte proliferation, and growth factor preservation that enhance wound healing in a moist environment and with regulated hydration can account for this. Apart from M. oleifera, several plant species have also been the focus of wound healing investigations; their aqueous leaf extract demonstrated notable wound healing potential. These species include Avicennia schaueriana, Morinda tinctoria Roxb and Albizia amara [1]. Moringa oleifera leaves (MOL) are well-known for their strong herbal extract and have a number of therapeutic qualities that help treat conditions like diabetes, cancer, heart disease, and atherosclerosis (Ningrum et al., 2023).

According to a study by Muzammil et al. (2023), M. oleifera leaf extracts may help diabetes patients heal wounds more quickly [2]. Acute hemostasis and the start of the inflammatory process trigger the proliferative phase, which is when angiogenesis, fibroplasia, and epithelialization start the process of wound repair. Following the end of the inflammatory phase, the wound region will experience neovascularization, which peaks in creation three to five days after the injury and starts to decline on the seventh day. As the wound heals [10]. The primary cells that affect the process of wound healing are macrophages [7].

In order to improve recovery for incision wounds, freshly generated collagen and fiber stabilization will boost the tissue tensile strength at the wound site. Higher hydroxyproline content, which aids in the healing of dead space wounds, was also linked to higher collagen content. Hydroxyproline, an amino acid present in the collagen fibers of granulation tissue, was measured in order to determine the amount of collagen. High

hydroxyproline net weight indicated high collagen content to support wound healing, which is utilized to estimate collagen synthesis. It was also believed that vitamins and minerals from plants helped to build collagen [1].

The tissue's tensile strength will rise with newly generated collagen and fiber stability at the wound location to promote the healing of wounds from incisions. Increased hydroxyproline content has also been linked to greater collagen content, which aids in the healing of dead space wounds. By quantifying hydroxyproline, an amino acid present in the collagen fibers of granulation tissue, the amount of collagen was determined. High collagen content to aid in wound healing was demonstrated by high hydroxyproline net weight, which is used to measure collagen formation.

Furthermore, it was believed that vitamins and minerals derived from plants helped to produce Collagen, One of Moringa oleifera's characteristics is its anti-inflammatory nature, which has been shown to inhibit inflammatory cells in a number of illnesses. Research revealed that giving Moringa oleifera extract decreased PMN cell infiltration into inflamed tissue [10].

CONCULSION

Moringa oleifera has demonstrated significant potential in promoting wound healing through its antimicrobial properties, antioxidant effects, and ability to enhance collagen production. To completely comprehend its bioactive components and safety for therapeutic applications, more research is required. *Moringa oleifera* has demonstrated significant wound healing potential due to its rich content of bioactive coMoringa oleifera has been shown to significantly enhance wound healing in various studies, particularly through its topical application. The plant's extracts have been effective in promoting wound contraction and epithelialization. compounds, including flavonoids, tannins, saponins, and essential vitamins. These constituents contribute to its anti-inflammatory, antioxidant, and antimicrobial properties, which are critical in accelerating the wound healing process. Experimental studies have shown that *Moringa oleifera* extracts promote faster wound contraction, enhanced epithelialization, and increased collagen deposition. Therefore, *Moringa oleifera* represents a promising natural alternative for wound care, supporting its traditional use in herbal medicine. However, further clinical research is needed to standardize its formulation and confirm its efficacy and safety in human populations.

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