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REVIEW ARTICLE

The Utilisation of Conventional Plant-based Treatments in Contemporary Wound Care

Prakash Chaudhari[1], Sakshi Srivastava[1], Jaya Patel[2*] and Carol P. Macwan[3]

[1]Department of Pharmaceutical Quality Assurance, Parul Institute of Pharmacy and Research, Parul University, Limda, Vadodara - 391760, Gujarat, India
[2]Department of Pharmacognosy, Parul Institute of Pharmacy and Research, Parul University, Limda, Vadodara - 391760, Gujarat, India; jaya1985@gmail.com
[3]Department of Pharmacognosy, Faculty of Pharmacy, Dharmsinh Desai University, Nadiad - 387001, Gujarat, India

Abstract

The word "wound" describes a break in living tissue's anatomical, functional, or cellular continuity. It is brought on by tissue damage from immunological, microbial, thermal, physical, and chemical causes. Wounds have been treated with various plants and plant-based products since ancient times. Many plant species and plant extracts show great promise for wound healing. Plant-based extracts promote blood coagulation, granulation, contraction, and skin tissue epithelisation, speeding up wound healing. This review's objective was to present a list of advanced wound healing treatments, Ayurvedic formulations and plants and plant parts that are undergoing preclinical and clinical testing. The popularity and signs of continued use of ancient traditions demonstrate that there are still important lessons to be learnt from them. According to the study's findings, medicinal plants such as *Aloe vera, Curcuma longa, Calotropis gigantea, Acalypha indica, Bacopa monnieri* and *Malva sylvestris* serve as a solid foundation for developing safer and more potent natural therapeutic agents for wound healing and related pathological conditions. Numerous natural polymers are presently being researched to develop stable, economical, eco-friendly and effective delivery systems for wound therapy. As demonstrated by their continued use and popularity, traditional methods still have a lot to teach us. A greater understanding of traditional practices results in greater appreciation and benefit for a greater number of people worldwide.
Major Findings: This review assesses the therapeutic potential of plant extracts for wound healing, highlighting medicinal plants like *Aloe vera* and *C. longa* as promising sources for natural healing agents. The authors also emphasize the ongoing relevance of traditional practices in modern medicine.

Keywords: Anti-inflammatory, Ayurvedic Formulation, Medicinal Plants, Plant-based Extracts, Wound Healing

1. Introduction

In both traditional and modern medicine, plants are widely utilised to cure and prevent disease. Plants have been utilised in the "*Ayurveda*" system of natural healthcare that has been used for over 5,000 years in India to prevent and treat disease. Eastern Asian countries use traditional Chinese medicine, which has been practiced for at least 3,000 years and makes use of a wide variety of plant species[1]. To learn about their bioactive components and create novel medications, contemporary science has extensively investigated plant species that have historically been utilised to treat disease. Numerous of these plant-derived substances are pharmacologically safe, according to investigations on the pharmacological mechanism that governs the action as well as the efficacy of such compounds, which promotes further investigation in preclinical studies and clinical trials. Although a significant part of the global population is unable to spend on these expensive drugs, adopting herbal medicines may help these patient groups[2]. Over the decades, a variety of formulations for skin issues such as wounds, burns, and cuts have been created using traditional herbs[3]. Under certain

*Author for correspondence

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research, only a few percent of medications in Western pharmacopeias have been utilised to treat cutaneous wounds, whereas traditional herbal therapies for such wounds represent roughly one-third of the available choices[4]. Traditional plants that have been historically utilised in folklore for treating wounds, adhering to scientific research, may provide a better alternative because they are comparatively affordable with no adverse reactions when compared with conventional synthetic techniques, including expensive plus unavoidable adverse effects[5]. The wound healing organisation defines wounds as injuries to the body that result in an opening or crack in the skin and disrupt the normal skin structure as well as function. Skin injuries result from the epithelium breaking down its continuity; however, regardless of underlying connective tissue is also lost[6]. It comprises three stages that overlap with one another, namely Inflammation, Proliferation and Remodelling. Abnormalities in wounds happen due to any kind of disturbances[7].

2. Classification[8,9]

Overall, wounds are categorised based on the underlying factor that led to the wound's development.

2.1 Acute Wounds

A systematically time-reparative phase that effectively recovers the integrity of both function and structure frequently occurs during an acute wound's tissue damage phase. Acute wounds are frequently resultant of injuries or surgical cuts.

2.2 Closed Wounds

A closed wound allows plasma to pass via the system that circulates blood, but it stays inside the body. Scars and injuries are prominent.

2.3 Open Wounds

It is easy to see the bleeding when there is an open wound because blood is dripping from the body. The open wound may further be categorised based on the source of the injury:

- Incised wounds
- Laceration or tear wounds
- Abrasions or superficial wounds
- Puncture wounds
- Penetration wounds
- Gunshot wounds.

2.4 Incised Wounds

There is minimal tissue damage and no tissue destruction in this incision. The main reasons are sharp objects like a razor or knife.

2.5 Laceration or Tear Wound

This non-surgical injury, when integrated with other kinds of stress, causes tissue to break down and decay.

2.6 Abrasive or Superficial Wounds

The process of abrasion is applied to a rough surface while sliding across it. This technique involves scraping off the epidermis, the outermost portion of the skin, which exposes nerve ends and results in an acute injury.

2.7 Puncture Wounds

These infections occur when something hits the surface of the skin, especially a pointed object or a sharp instrument. Infection is quite likely because dirt may get very far into the incision.

2.7.1 Penetration Wounds

The main source of penetration wounds is something like an object poking through and out of the layer of skin.

2.7.2 Gunshot Wounds

A bullet or other object which enters or passes through a body part might cause injuries.

2.7.3 Chronic Wounds

Chronic wounds are those that are not currently going through the normal phases of healing, yet have instead progressed to a level of pathologic inflammation process that generally requires more healing time.

Localised infections, low oxygen levels, trauma, foreign objects and systemic conditions including obesity, diabetes, nutritional deficiency, immune deficiency, or medications are the most frequent causes of chronic wounds. A few examples of chronic sores include foot ulcers caused by diabetes, pressure ulcers and venous leg ulcers.

3. Influencing Factors for Wound Healing

3.1 Oxygenation

The metabolic function of cells, especially the Adenosine Triphosphate (ATP)-based energy generation process, depends on oxygen, as do nearly all wound healing mechanisms. It stimulates blood vessel formation, increases keratinocyte differentiation, migration, and re-epithelialisation, accelerates fibroblast proliferation and collagen formation, and helps wounds heal more quickly. It also prevents wounds from becoming infected.

The earliest wound environment is significantly oxygen-depleted, along with hypoxic, with regard to absorption by active metabolism cells. Aging and diabetes are two systemic illnesses that will result in decreased vascular flow, which will lead to insufficient oxygen in the tissue. Insufficient oxygenation combined with this causes a chronic wound that cannot heal.

3.2 Infections[10]

Unless the layer of skin gets damaged, microorganisms that are frequently restrained on the skin's surface get entry into the layers of tissue underneath. The current stage of infection and the microorganism's ability to replicate depend on whether the wound has been identified as inflamed, colonised, locally invaded/critically colonised, or spreading invasive. Contamination is the appearance of non-replicating organisms, whereas colonisation is the presence of replicating microbes on the wound without resulting in tissue harm. Local infection/critical colonisation, which involves microbial growth and the beginning of local tissue actions, is an intermediate phase. Microorganisms reproduce in a wound and harm the body of the host as a result. These are known as "Invasive Infections". Inflammation is necessary for the elimination of microbes that are infectious and is a typical part of the healing process for wounds.

However, due to insufficient microbial clearance, inflammation might persist even in the absence of proper disinfection. Interleukin-1 (IL-1) and TNF-alpha are two pro-inflammatory cytokines that are elevated over time and prolong the inflammatory process by promoting the growth of bacteria and endotoxins. If this keeps happening, the wound can become chronic and stop healing. A higher concentration of Matrix Metalloproteases (MMPs), a protease class that may break down the extracellular matrix, is also a result of protracted inflammation. There is a decrease in the amount of naturally occurring inhibiting protease along with a rise in protease activity. Due to this change in protease equilibrium, proliferative factors that are present in prolonged wounds may rapidly degrade.

3.3 Elderly Age

A delay in wound healing has been linked to aging. It has been shown that in wounded elderly people, fibroblast proliferation and activity decline, the production of collagen slows down, and wound contraction decreases.

3.4 Psychological Stress Modulates Healing Processes

Stress strongly impacts the way people interact with one another in social environments. Stress is associated with several disorders, including diabetes, cancer, and impaired wound healing, and cancer. Numerous studies have suggested, stress-related malfunction of the neuroendocrine-immune system is essential for health. Stressed individuals are more susceptible to participating in harmful habits like insomnia, an inadequate diet, a lack of exercise, and a greater chance of smoking, using nicotine-based products, or consuming additional drugs. This is in addition to the direct effects of depressive disorders and anxiety on endocrine and immunological function.

3.5 Body Type

The physical characteristics of the body can affect how quickly wounds heal. For instance, a patient who is obese may have compromised wound healing because of insufficient blood flow to the adipose tissue. Several fatty human beings also suffer from protein deficiency, which inhibits recovery further. On the other hand, once a patient is severely undernourished and lacking in oxygen, this could delay the healing of wounds.

3.6 Chronic Diseases

Chronic conditions such as diabetes mellitus, peripheral vascular disease, coronary heart disease, and stroke may

all cause a delay in the healing of wounds. To use the best strategy, patients with chronic illnesses should be followed up on often during their course of medication.

3.7 Vascular Insufficiency

The lower extremities can be affected by a variety of lesions or ulcers, including arterial, pressure, diabetic and venous ulcers. The physician has to figure out the type of ulcer to administer proper topical treatment as well as supportive medications.

3.8 Nutrition

Food has been established for more than a century as having a substantial influence on how effectively wounds heal. The most obvious factor is that wound healing can be significantly impacted by nutritional deficiencies following trauma and surgery. Patients with persistent wounds, non-healing wounds, and malnutrition require additional essential vitamins and minerals. So, the healing process is impacted by how the body uses energy, carbs, proteins, fats, vitamins, and minerals.

3.9 Improper Diet

Anabolic processes like wound healing need both energy and nutrient substrates to function. According to reports, a serum albumin level of 3.5 gm/dl or above is required for effective recovery.

Collagen production at the location of a wound depends on the protein. A state of malnutrition may offer insufficient protein, which might slow down collagen formation, weaken the tensile strength of wounds, or raise the risk of infection.

4. Mechanism of Wound Healing

An allergic reaction, propagation and remodelling are three concurrent steps of the complicated system that heals wounds. A proliferative wound-healing response is brought on by the inflammatory process, and it is further distinguished by vascular processes, including blood coagulation and hemostasis. Cellular activity includes the invasion of leukocytes and the release of cytokines and antimicrobial therapy. The epithelium develops during the proliferative phase to cover the wound surface, and granulation tissue then grows to fill the wound area. Granulation tissue is produced through fibroblast proliferation, collagen deposition, the development of new blood vessels, and the deposition of another extracellular matrix. The remodeling phase begins when new connective tissue grows inside the incision, restoring the tissue's structural integrity and functional competency. The three distinct phases of wound healing, nevertheless, don't follow a straight line and take different amounts of time[11]. Burns, other serious traumas, and wounds from surgery are examples of acute wounds that recover quickly. An incisional surgical wound that is tidy, uninfected and approximated by operational sutures is an example of a typical acute wound. With important exceptions like early fetal healing, regeneration is rarely achieved, even though organised healing aims to create tissues with the same structure and capabilities as skin that has been retained. Healing produces a product that is physically and functionally acceptable but not identical. Different growth hormones and cytokines secreted at the wound site often rigorously govern how quickly wounds heal. Changes that prevent fast, controlled healing increase injury to tissues and prolong recovery[12] (Figure 1).

4.1 Inflammatory Phase

The inflammatory phase starts as soon as the damage occurs, often lasting between 24 and 48 hours but frequently lasting up to two weeks. The hemostatic mechanisms are triggered during the inflammatory phase to prevent bleeding from the wound site promptly. The clinically observable cardinal signs of inflammation include rubor (redness), tumor (swelling), calor (warmth), dolor (pain), and function laesa (loss of function). Vasoconstriction and platelet aggregation cause blood to clot during this phase, promptly followed by phagocytosis and vasodilation, resulting in inflammation at the wound's site.

4.2 Proliferative Phase

After the inflammatory phase, the proliferative phase, which can last between two to three weeks, is the next stage of wound healing. The entire process is comprised of the granulation, contraction, and epithelialisation phases. Fibroblasts create a collagen bed and create new capillaries during the granulation stage. Glycosaminoglycans and collagen, among other chemicals produced by fibroblasts, are crucial for wound healing[13]. During the contraction phase,

wound ends come together to remove irregularities. In the third stage, new epithelial tissues are generated over the wound site.

4.3 Remodelling Phase

This time frame ranges from three weeks to a period of two years. During this stage, new collagen grows[3-14]. Collagen's intermolecular cross-linking through vitamin C-dependent hydroxylation increases tissue tensile strength. When a scar flattens, the surrounding tissues become stronger by 80% compared to the original tissue.

5. Medicinal Plants for Wound Treatment

For centuries, several medicinal herbs have been utilised to control and cure multiple types of wounds. Despite significant advancements in the field of contemporary medicine, medicinal plants continue to be an important part of the current approach to wound treatment[17] (Tables 1-3).

The Plant *Bacopa monnieri* (faster re-epithelialisation) is one of the medicinal herbs claimed to speed up wound healing[18]. *Acalypha indica* (boosts cell division), *Calotropis gigantea* is a plant that can help in scar reduction[19], and *Aloe vera* can promote new blood vessel growth. *Aloe vera* has been used to treat wounds for over 5000 years by the Egyptians, Romans, and native populations of Africa, Asia, and the Americas. It is still the first choice for treating burns, ulcers and surgical wounds. One of *Aloe vera's* main mucopolysaccharides, or mesoglycans, acemannan, strongly stimulates T-cell and macrophage activity as well as the production of proinflammatory mRNAs[20], Turmeric is used as an inflammatory treatment by traditional Ayurvedic physicians. Target pathways include NF-κB, cyclooxygenase2, 5-LOX, STAT3, proinflammatory cytokines, apoptosis, prostaglandin E2, prostate-specific antigen, C-reactive protein, phosphorylase kinase, transforming growth factor-β, triglycerides, ET-1, creatinine, heme oxygenase-1, AST, and ALT. Thus, it should come as no surprise that *Curcumin* promotes the growth of granulation tissue, collagen deposition, and fibroblast proliferation during the healing of cutaneous wounds[21], *Malva sylvestris* can help the body's blood vessels proliferate[22] and *Glycyrrhiza glabra*[23] helps in wound contraction.

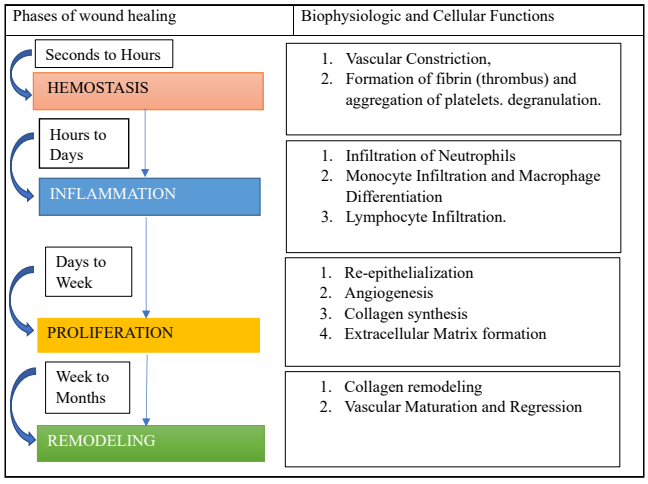


Figure 1. Different stages of wound-healing.

5.1 *Arctium lappa* (Burdock)

In North America, Europe, and Asia, *Arctium lappa* is used to treat skin conditions like acne, rashes, and boils as well as sore throats. Scientific investigations show that *A. lappa* possesses antiviral, antibacterial, antidiabetic, and antioxidant properties. *Arctium lappa* root extract has been demonstrated to dramatically enhance dermal extracellular matrix metabolism, impacting glycosaminoglycan turnover and mitigating wrinkle appearance in human skin *in vivo*. In canine dermal fibroblasts, *A. lappa* has also been shown to control gene expression and cell adhesion.

5.2 *Astragalus propinquus* (Mangolian Milkvetch) and *Rehmannia glutinosa* (Chinese Foxglove)

This has an impact on the Wnt/β-catenin signaling pathway, which is recognised as a crucial regulator of wound healing. *Astragalus propinquus* root is commonly used in Traditional Chinese Medicine (TCM) to treat oedema and urine retention, whereas *Rehmannia glutinosa* root is widely utilised in hemorheology and diabetes-related disorders. It was first noted that a combination of *R. glutinosa* and *A. propinquus* root was clinically useful in treating diabetic foot ulcers. Both *A. propinquus* and *R. glutinosa* stimulate enhanced Extracellular Matrix (ECM) deposition in human skin fibroblasts by activating the TGF-β1 signaling pathway.

5.3 *Ampelopsis japonica* (Japanese Peppervine)

Among other things, burns and ulcers are traditionally treated with the roots of *Ampelopsis japonica*. *Ampelopsis japonica* has been shown to have a variety of pharmacological properties, including antibacterial and neuroprotective properties. Two days after the damage, tumor necrosis factor-alpha (TNF-α) and tumor growth factor-β1 were found to be increased, but as the body healed, they decreased. Topical therapy with ethanolic *A. japonica* increased reepithelialisation, granulation tissue development, vascularisation and collagen deposition when compared to wounds treated with Vaseline (petroleum jelly) or silver sulfadiazine.

5.4 *Blumea balsamifera* (Sambong)

Also referred to as Sambong, *Blumea balsamifera* is a diuretic. It is used to cure fevers, coughs, pains, and rheumatism. To cure eczema, dermatitis, bruising, beriberi, lumbago, menorrhagia, rheumatism and skin injuries, leaf extracts are administered directly. By encouraging angiogenesis, perfusion, collagen deposition, the creation of organised granulation tissue, reepithelialisation, and wound closure, *B. balsamifera* enhances wound healing in mice.

5.5 *Calendula officinalis* (Pot Marigold)

The plant *Calendula officinalis*, also referred to as pot marigold, is incredibly widespread and is used to treat a wide range of skin ailments, including burns, wounds, and dermatitis. *Calendula officinalis* is said to possess a variety of pharmacological properties, such as anti-inflammatory, antioxidant, antibacterial, antiviral, antifungal and anticancer properties. Research employing fibroblast cultures from humans and mice revealed that *C. officinalis* extracts stimulate fibroblast migration and proliferation in a way that is dependent on PI3K.

5.6 *Celosia argentea* (Silver Cockscomb)

In traditional medicine, *Celosia argentea*, sometimes referred to as silver cock's comb, is used to treat skin lesions, eruptions, ulcers, mouth ulcers and other skin conditions. This plant's leaf extracts have hepatoprotective and antioxidant properties. *Celosia argentea* increases the amount of collagen and hexosamine in granulation tissue wounds, which speeds up the closure of burn wounds in rats. Furthermore, the extract promoted primary rat dermal fibroblasts' motility and proliferation.

5.7 *Centella asiatica* (Asiatic Pennywort)

Asiatic pennywort, or *C. asiatica*, has long been used to accelerate the healing of wounds. Chronic ulcers are said to heal more quickly when *C. asiatica* is used. Rats with acute radiation dermatitis wounds were shown to heal faster in the *C. asiatica* extract treatment group than in the no-treatment group. In a wound model of rats, *C. asiatica* increases the synthesis of glycosaminoglycan and the remodeling of collagen.

5.8 *Commiphora myrrha* (Myrrh)

Commiphora myrrha possesses established properties such as antioxidant, anti-inflammatory, antibacterial, and analgesic effects. Myrrh is applied topically for wound cleansing, oedema reduction and analgesia (pain alleviation).

5.9 *Daphne genkwa* (Blue Daphne)

The Extracellular Signal-Regulated Kinase (ERK)/ Mitogen Activated Protein Kinase (MEK) pathway, which controls fibroblast proliferation and collagen (COL1A1 and COL3A1) expression, is stimulated by *Daphne genkwa*, which acts as an anticonvulsant, painkiller, diuretic, antitussive, expectorant, and light sedative. This leads to better wound healing.

5.10 *Ganoderma lucidum* (Lingzi)

Numerous pharmacobiological reactions, including immunological modulation, inflammatory modulation, and anti-infective responses, are stimulated by *Ganoderma lucidum*. The best results from *Ganoderma lucidum* come from using it as a supplement to other treatments. In diabetic rats, polysaccharide extracts from *G. lucidum's* fruiting body have been demonstrated to accelerate wound healing, possibly via promoting fibroblast migration and proliferation.

5.11 *Panax ginseng* (Asian Ginseng)

It has been shown that *Panax ginseng* has the following effects: it causes vasodilation, regulates blood cholesterol levels, lessens inflammation, and

has anti-aging, antioxidant, anti-cancer, antibacterial, and immunomodulating properties. It has been demonstrated that *Panax ginseng* root extracts protect C57BL mice's skin from acute Ultraviolet Radiation (UV) B irradiation and greatly accelerate the healing process following laser burn injuries and excisional wounds. Extracts from *P. ginseng* improve the migration of keratinocytes and stimulate the production of collagen by human dermal fibroblasts. Choi proved that the ginsenoside Rb2, which is extracted from *P. ginseng*, causes the epidermis to form in raft culture by upregulating the expression of fibronectin and its receptor, keratin 5/14 and collagenase I, as well as epidermal growth factor and its receptor. These molecules are all essential for wound healing.

5.12 *Panax notoginseng* (Chinese Ginseng)

Panax notoginseng is used to lessen pain, bruising, oedema, and bleeding. Significant pharmacological activities of *P. notoginseng* include anti-inflammatory and antioxidative properties. Terpene saponins promote angiogenesis and Vasco Endothelial Growth Factor (VEGF) expression, two essential processes in wound healing. According to studies on the mechanism of action, extracts from the flowers of *P. notoginseng* inhibit NF-κB signalling, which in turn affects the

Table 1. List of medicinal plants with wound-healing activity[40- 52]

Sr.No	Medicinal Plants	Part Used	Bioactivities	Active Ingredients	Clinical Uses	Formulation	Marketed Product
1	*Aloe vera*	Leaves	Immunomodulatory Antidiabetic Anti-inflammatory	Acemannan	Wound healing	Gel	*Aloe vera* gel
2	*Arctium lappa*	Leaves Whole root	Antimicrobial Antiviral	Inulin, Tannin	Burns Rashes	Ointment	Not available
3	*Astragalus propinquus Rehmannia glutinosa*	Roots	Anti-inflammatory	Astragaloside IV, Calycosin, Catalpol	Diabetic foot ulcer	Herbal drink	Not available
4	*Ampelopsis japonica*	Root tuber	Anticancer Neuroprotective	Catechins, Epicatechin, gallate	Burns Ulcers	Wound plaster	Hydrating Moisturiser
5	*Blumea balsamifera*	Leaves	Antifungal Antiobesity Antiplasmodial Antitumour	L-Borneol	Dermatitis Eczema Skin bruises Skin injury	Oil	Blumea leaf oil
6	*Calendula officinalis*	Flower	Antifungal Anti-inflammatory Antioxidant Antiviral	Esculetin, Quercetin-3-O-glucoside	Burns Dermatitis Wounds	Topical spray Oil	Calendula Herbal Extract Toner Plenusdermax®
7	*Celosia argentea*	Leaves	Antimicrobial Antioxidant Hepatoprotective	Celosin I, Celosin II	Skin sores Ulcers	Poultice of stems and leaves [topically]	Not available
8	*Centella asiatica*	Aerial parts	Anti-inflammatory Antioxidant Proangiogenic	Asiaticosid	Wounds	Oral form (tablets, drops) Topical medication Injections	Madecassol® Centellase®
9	*Commiphora myrrha*	Leaves and resin	Analgesic Antibacterial Anti-inflammatory Antioxidant	Furanoeu desma-1,3- diene Terpene	Wounds and pain	Oil	Myrrh essential oil

Table 1. Continued...

10	*Curcuma longa Jiang H*	Rhizomes	Antibacterial Anti-inflammatory Antioxidant	Curcuminoids	Wounds	Capsules	CAVACURMIN®, Biocurcumax ™
11	*Daphne genkwa*	Flower Root	Anti-inflammatory Antitumour	Daphnodorin H Daphnodorin H 3- methyl	Wounds	Not available	Not available
12	*Ganoderma lucidum*	Fruiting body	Anti-infective Anti-inflammatory	Ganoderma lucidum polysaccharide	Ulcer	Not available	Ganoderma lucidum spores powder capsules
13	*Panax ginseng*	Leaves, root, and whole plant	Antiaging Antiallergic Anticancer Anti-inflammatory Antimicrobial Antioxidant	Ginsenosides Rb1, Rb2, Rc, and Rd	Wound healing	Not available	Ginseng Strong 200 mg Ginsemax® Ginseng Vita. Complex
14	*Panax notoginseng*	Leaves, flowers, roots, and rhizome	Anticancer Antidiabetes Anti-inflammatory Antioxidative	Notoginsenoside Ft1	Trauma	Powder on wound Spray on wound	Yunnan Baiyao
15	*Lithospermum erythrorhizon*	Roots	Antibacterial Anti-inflammatory	Arnebin- 1	Wounds	Oil formulations, gel	Burt's bee Res-Q ointment

Table 2. Analytical methods for different phytoconstituents[53-61]

Sr. No	Phyto constituents	Description			Result	References
		Analytical Method	Stationary hase	Mobile Phase		
1	Inulin	HPTLC	Silica gel 60 F_{254}	Butanol: Ethanol: Water (60:24:16 v/v/v)	R_f: 0.43	53
2	Astraga loside IV	HPLC	Cosmosil C_{18} (5 µm, 150 mm × 2.0 mm)	Acetonitrile: water containing 5 µM NaAc (40:60, v/v)	R_t: 3.4 min.	54
3	Catechin	HPLC	Jupiter C18 column (250×4.6mm, 5µm)	Methanol: CAN: Water (55:40:5)	R_t: 6.75 min.	55
4	Catalpol	HPLC	C18 column (4.6 mm × 100 mm, 2.6 µm)	Acetonitrile: 0.1% formic acid in water (5:95, v/v)	R_t: 3.43 min.	56
5	Esculetin	HPTLC	Silica gel 60 F_{254}	Ethyl acetate: Methanol: Water: Glacial acetic acid (20:2:1:4, v/v/v/v)	R_f: 0.36	57
6	Celosin I	HPLC	Agilent ZORBAX C18 column (250 mm × 4.6 mm, 5 µm)	Acetonitrile: 0.1% Aqueous acetic acid (32:68, v/v)	R_t: 12.5 min.	58
7	Asiaticosid	HPLC	RP 18 (511m) column 125 x 4 mm	Water: Acetonitrile (70:30 v/v)	R_t: 18.0 min.	59
8	Curcumin	HPLC	C18 column (150 × 4.6 mm, 5 µm)	Acetonitrile: 2% Acetic acid (40:60, v/v)	R_t: 12.0 min.	60
9	Ganoderma lucidum	HPTLC	Silica gel 60 F_{254}	Toluene: Tetrahydrofuran: Acetic acid (70:30:1 v/v/v)	R_f: 0.45	61

Table 3. Ayurvedic formulations used for wound healing treatment[62]

Sr. No.	Ayurvedic Formulations	Sr. No.	Ayurvedic Formulations
1	*Mrdvikarista*	8	*Jatyadi taila*
2	*Nyagrodhadhi kwatha churna*	9	*Vajraka taila*
3	*Kancara guggul*	10	*Vranaraksasa taila*
4	*Kaisor guggul*	11	*Sinduralepa*
5	*Jatyadi ghrta*	12	*Lakshmivilasa rasa*
6	*Nimbadi churna*	13	*Caturmukha rasa*
7	*Jatyadi taila*	14	*Caturmukha rasa*

Table 4. Currently available wound care dressings[63]

Sr.no	Current Types of Dressing	Marketed Available Products	Observation
1	Gauze	Curity, Vaseline gauze.	Cost-effective, drying, and altering it could lead to more damage
2	Films	Blister film, Tegaderm	Only suitable for non-exudative wounds, occlusive, and moisture-retaining
3	Hydrocolloids	Aquacel, Tegasorb, DuoDERM	Longer intervals between modifications, fluid-trapping, occlusive, not for wounds that are infection-prone
4	Hydrogels	Curagel, Nu-Gel, Purilon, SAF-gel, XCell	Rehydrates dry wounds, is simple to remove or replace, but may result in excessive water intake
5	Foams	3M Adhesive Foam, Allevyn, Lyofoam.	Gently absorbing and insulating
6	Alginates	Algisite, Kaltostat, Tegagen	Extremely absorbent as well as hemostatic

release of inflammatory cytokines like IL-6, which are known to have a role in keloid formation.

5.13 *Lithospermum erythrorhizon* (Purple Gromwell)

In cancer cell lines, *Lithospermum erythrorhizon* induces caspases, poly-(ADP-ribosyl) Polymerase (PARP), and Reactive Oxygen Species (ROS), which in turn cause programmed cell death. According to these investigations, shikonin prevents human skin fibroblasts originating from hypertrophic scars from proliferating and producing collagen. In a rat diabetic model, it has been found that Arnebin-1, a similar naphthoquinone isolated from *L. erythrorhizon*, synergises with VEGF to greatly increase wound healing[24-39].

6. Basic Procedures for Therapy

These can include the following:

- Conducting a detailed assessment of the wound's characteristics, including size, depth, and overall condition.
- Carefully performing a thorough cleaning of the wound to remove any contaminants and promote an optimal healing environment.
- Effectively eliminating any necrotic tissue through debridement, ensuring that healthy tissue can flourish and heal properly.
- Selecting an appropriate dressing that not only protects the wound but also supports the healing process and accommodates the specific type of wound.
- Implementing compression therapy, if necessary, to promote circulation and reduce swelling in the affected area, aiding in the recovery process (Table 4).

7. Clinical Importance

It is important to understand that chronic wound development or excessive healing can occur when there are disruptions in the natural stages of wound healing. This can be a frustrating and challenging experience for those affected, as healing is a vital part of recovery.

8. Prospective Vision and Conclusion

It is not surprising that there is a lot of activity in the field of wound healing research, given the significant importance of wound healing in both economics and patient care. Many new investigations on wound healing come from apparently unrelated fields, such as the field of materials science and molecular biology, among others. Due to their natural skin healing capabilities, several herbal plants offer substantial promise for medicinal use in wound healing. There are a lot of isolated phytoconstituents and herbal extracts utilised today for their capacity to heal wounds. Numerous ayurvedic, allopathic, and herbal preparations are now employed in wound treatment due to technological advancements. Because they are safer than allopathic medications, herbal medications and formulations are becoming more and more popular in industrialised nations.

9. Author Contribution

All authors contributed to the data collection process. Dr. Jaya Patel directed the design and conceptual framework of the manuscript. The writing was a collaborative effort among all authors, while Mr. Prakash Chaudhari skillfully developed the figures and tables. Dr. Jaya Patel and Dr. Carol. P. Macwan conducted a thorough review of the manuscript. Ms. Shakshi Shrivastava was responsible for the formatting and compilation of the bibliography. All authors have read and agreed to the published version of the manuscript.

10. References

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