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## **REVIEW ON: MECHANISM OF WOUND HEALING AND MEDICINAL IMPORTANCE OF HERBS IN WOUND HEALING FORMULATION**

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### **ABSTRACT :**

Wound healing is a fundamental physiological process essential for the restoration of tissue integrity and function following injury. The mechanism of wound healing unfolds through a series of coordinated phases, including hemostasis, inflammation, proliferation, and remodeling. Herbal remedies have long been utilized in traditional medicine systems worldwide for their therapeutic properties in wound healing. Numerous herbs contain bioactive compounds with antimicrobial, anti-inflammatory, and pro-regenerative effects, making them valuable adjuncts in wound care. Calendula, Turmeric, aloe vera, and Neem are among the herbs commonly employed in wound healing preparations due to their demonstrated efficacy in promoting tissue regeneration and reducing inflammation.

**Keywords:**wound,calendula,anti-inflamatory,Anti-oxidant,proliferation.

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### **Introduction :**

The human skin, the body's largest organ, serves as its primary defense mechanism. Alongside protection, it performs vital functions in regulation and sensation. It shields against mechanical forces, pressure, temperature fluctuations, microbial threats, radiation, and chemical intrusion. Additionally, the skin regulates body temperature through sweat and hair, and influences peripheral circulation and fluid equilibrium, making it pivotal in various physiological processes.[1]

Wounds are common occurrences in everyday life, defined as disruptions in the continuity of living tissue due to injury. They often bring discomfort and are susceptible to infections and other complications. Various factors such as immune deficiencies, ischemia, malnutrition, aging, local infections, and tissue damage can hinder the healing process, leading to delays.

Wound healing is a complex process where the skin repairs itself following injury. It comprises three phases: inflammatory, proliferative, and remodeling. During the inflammatory phase, there is an increase in blood flow, capillary permeability, and leukocyte migration to the affected area. The proliferative phase is characterized by granulation tissue formation, wound contraction, and epithelialization. The remodeling phase determines the strength and appearance of the healed tissue.[2]

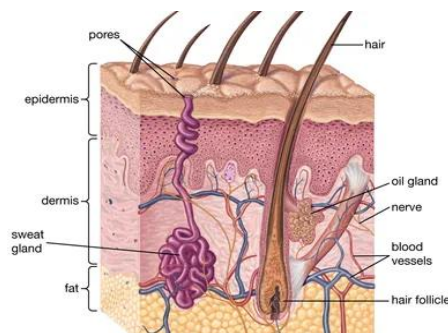
In numerous Asian nations, herbal products hold significant importance in treating wounds, burns, intestinal issues, coughs, and general lethargy. Utilizing traditional remedies and medicinal plants for burns and wounds not only forms a crucial part of healthcare management but also offers cost-effective healthcare alternatives. Effective wound healing relies on the removal and prevention of infections. Many studies have provided both in vitro and in vivo evidence supporting the efficacy of various plant materials as topical antimicrobial agents to expedite wound healing. Folkloric traditions and the Ayurvedic system of medicine have documented numerous indigenous plants and formulations for managing cuts, bruises, burns, and wounds the use of *Murraya koenigii* could be a possible candidate in wound healing since it is widely used in traditional medicine. Well known for its aromatics, *M. koenigii* is consumed in many Asian cuisines. The leaves had been reported to possess pharmacological activities as stimulants, tonics, and as carminative agents to treat influenza, fever, bronchial asthma and animal bites.[3]

*Calendula officinalis*, a member of the Asteraceae family, is a widely cultivated garden plant valued for its medicinal properties across Europe, China, the United States, and India. It is known by several common names, including African Marigold, Calendula, and Common Marigold. [4]

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### **Anatomy Of The Skin :**

The skin is the largest organ of the human body and serves as a protective barrier between the internal organs and the external environment. It consists of three main layers: the epidermis, the dermis, and the hypodermis (subcutaneous tissue)



**Fig.1 Structure of Skin**

### 1. Epidermis:

The epidermis is the outermost layer of the skin and is primarily composed of epithelial cells. It provides waterproofing and protection against environmental factors such as pathogens, UV radiation, and chemicals. The epidermis consists of several sublayers:

- **Stratum Corneum:** The outermost layer of the epidermis, composed of dead, keratinized cells called corneocytes. It serves as a barrier to water loss and external substances.
- **Stratum Lucidum:** A translucent layer found only in thick skin, such as the palms of the hands and soles of the feet.
- **Stratum Granulosum:** Composed of granular cells that produce keratin, a tough protein that provides strength to the skin.
- **Stratum Spinosum:** Contains spiny-shaped cells called keratinocytes, which provide structural support to the skin.
- **Stratum Basale (Basal Layer):** The deepest layer of the epidermis, composed of basal cells that continuously divide to replenish the outer layers of the epidermis. It also contains melanocytes, which produce melanin, the pigment responsible for skin color.

### 2. Dermis:

The dermis is the middle layer of the skin, located beneath the epidermis. It consists of connective tissue, blood vessels, nerves, hair follicles, sweat glands, and sebaceous glands. The dermis provides structural support, elasticity, and nourishment to the skin. It contains two main layers:

- **Papillary Dermis:** The upper layer of the dermis, composed of loose connective tissue that forms finger-like projections called dermal papillae. These papillae interlock with the epidermis and contain blood vessels, nerve endings, and Meissner's corpuscles (touch receptors).
- **Reticular Dermis:** The deeper layer of the dermis, composed of dense irregular connective tissue containing collagen and elastin fibers. It provides strength and elasticity to the skin and contains structures such as blood vessels, hair follicles, sweat glands, and Pacinian corpuscles (pressure receptors).

### 3. Hypodermis (Subcutaneous Tissue):

The hypodermis is the deepest layer of the skin, located beneath the dermis. It consists of adipose (fat) tissue and loose connective tissue, providing insulation, cushioning, and energy storage. The hypodermis also contains larger blood vessels and nerves that supply the skin and underlying tissues.

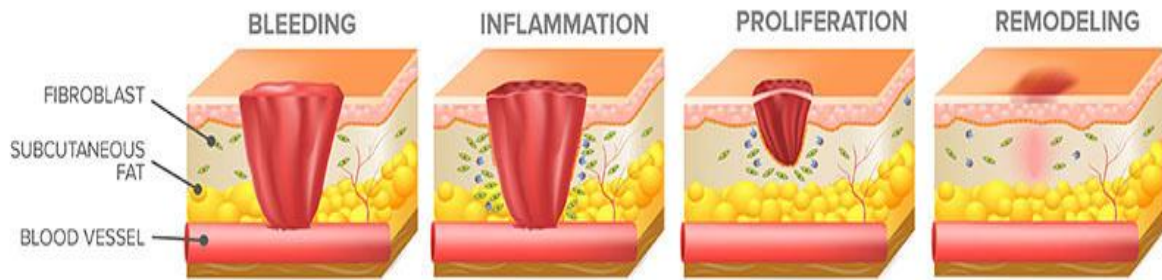
**The skin also contains various accessory structures, including:**

- **Hair:** Produced by hair follicles in the dermis and serves to insulate the body and protect the skin from mechanical damage.
- **Nails:** Formed by specialized epithelial cells in the nail matrix and provide protection to the fingertips.
- **Sweat Glands:** Produce sweat to regulate body temperature and excrete waste products.
- **Sebaceous Glands:** Secrete sebum, an oily substance that lubricates and waterproofs the skin and hair.
- **Blood Vessels:** Supply oxygen and nutrients to the skin cells and help regulate body temperature.
- **Nerves:** Transmit sensory information such as touch, temperature, and pain signals to the brain. [10]

## MECHANISM OF WOUND HEALING :

Wound healing is a complex mechanism that can be categorized as an allergic response, propagation, and remodelling in three parallel phases. The inflammatory process initiates a proliferative wound repair response further characterized by vascular responses like blood coagulation and hemostasis. Cellular activities include leukocyte infiltration with the release of antimicrobials and cytokines. During the proliferative process, the epithelium is formed to coat the wound surface with the subsequent growth of granulation tissue to fill the wound space. The generation of granulation tissue includes fibroblast proliferation, collagen deposition as well as other extracellular matrices, and the development of new blood vessels. The remodelling process begins to restore structural integrity and functional competence to the tissue when the new tissue is established inside the wound. The retained skin, but Regeneration is rare (with significant exceptions, such as Early fetal healing). Thus, healing results in an outcome that is structurally and functionally adequate but not equivalent. Wound healing processes tend to be strictly regulated at the wound site by various growth factors and cytokines released. Changes that interfere with regulated timely healing processes increase tissue damage and stages of wound healing, however, are not simple linear procedures, but instead, vary in time. Acute wounds, like burns, other severe injuries, and wounds sustained by surgery, relate to those injuries that heal quickly. An example of a typical acute wound is a neat and uninfected incisional surgical wound approximated by operative sutures. While the desired end Product of organized healing is tissue production with Similar structure and functions as with delay recovery.[5]

## Phases of Wound Healing



**Fig .2 phases of wound Healing**

Wound healing is the complex and dynamic process of replacing and missing cellular structure and tissue layer. The adult human wound healing is divided into four phases.

1. **Inflammatory phase**
2. **Hemostasis Phase**
3. **proliferative phase**
4. **Remodeling phase**

### 1. Hemostasis

- This phase begins immediately after injury to stop bleeding and prevent further blood loss.
- Blood vessels in the vicinity of the wound constrict (vasoconstriction) to reduce blood flow.
- Platelets adhere to the site of injury and aggregate, forming a temporary plug.
- Clotting factors in the blood trigger the coagulation cascade, leading to the formation of a stable blood clot.
- This phase typically lasts for a short period, usually minutes to hours, depending on the severity of the injury.

### 2. Inflammatory Phase

- This phase starts shortly after hemostasis and lasts for several days.
- Inflammatory cells, such as neutrophils and macrophages, migrate to the wound site to remove debris, bacteria, and damaged tissue.
- Various chemical signals, including cytokines and growth factors, are released to recruit inflammatory cells and initiate tissue repair.
- Inflammation helps create an environment conducive to healing by promoting angiogenesis (formation of new blood vessels) and stimulating the proliferation of fibroblasts.

### 3. Proliferative Phase

- This phase typically begins around day 3 or 4 after injury and can last for several weeks.
- Fibroblasts migrate to the wound site and begin synthesizing collagen, a structural protein that forms the framework for new tissue.
- Granulation tissue, characterized by its pinkish-red appearance and rich blood supply, fills the wound bed.
- Epithelial cells at the wound edges proliferate and migrate across the wound surface, eventually covering the wound with new epithelium.
- Angiogenesis continues to supply the developing tissue with oxygen and nutrients.

### 4. Remodeling Phase

- Also known as the maturation phase, this phase begins around week 3 and can last for months to years.
- Collagen fibers undergo remodeling, becoming more organized and cross-linked to increase tensile strength.
- Excess granulation tissue is gradually resorbed, and the wound contracts in size.
- The wound gains strength and flexibility as it matures, although it may never fully recover its original tensile strength.
- Scar tissue forms, which is often different in texture and appearance from the surrounding tissue.
- The final outcome of wound healing depends on various factors, including the type and extent of the injury, the presence of underlying health conditions, and the effectiveness of wound care and management.[6]

## Classification of wounds :

Wounds can be classified based on several criteria, with time being a significant factor in injury management and wound repair. Therefore, clinically, wounds can be categorized as either acute or chronic depending on their timeframe for healing .

### 1. Open wound

In such instances, blood loss occurs externally, and the bleeding is visibly apparent. This type of wound is categorized as follows: incised wound, laceration (tear wound), abrasions (superficial wounds), puncture wounds, penetration wounds, and gunshot wounds.

### 2. Closed Wound

In closed wounds, blood exits the circulatory system but remains confined within the body. This category encompasses contusions (bruises), hematomas (blood tumors), crush injuries, and similar conditions.

### 3. Acute wound

Acute wounds are those that undergo self-repair, following a timely and organized healing process, resulting in both functional and anatomical restoration. Typically, these wounds heal within a period ranging from 5 to 10 days, or within 30 days at most. They can arise from traumatic tissue loss or surgical procedures. For instance, surgery to extract a soft tissue tumor from the skin and underlying tissue may yield a sizable, uncontaminated wound. However, due to the substantial tissue loss incurred, this wound may not be able to undergo primary intention healing, primarily because of the significant defect within the tissue.

### 4. Chronic Wound

Chronic wounds are characterized by their inability to advance through the typical stages of healing in an orderly and timely manner. The healing process is disrupted by various factors, which extend one or more stages within the phases of hemostasis, inflammation, proliferation, or remodeling. These factors encompass infection, tissue hypoxia, necrosis, excessive exudate, and elevated levels of inflammatory cytokines. Persistent inflammation within the wound initiates a series of tissue reactions that sustain a non-healing condition. Consequently, healing progresses in a disorganized manner, leading to unsatisfactory functional and anatomical outcomes, often resulting in recurrent wounds. Various factors can contribute to the development of chronic wounds, including natural processes, pressure, arterial and venous insufficiency, burns, and vasculitis.[7]

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## Need of Herbal Remedies in Antibacterial, Antifungal and wound healing action.

The need for herbs in wound healing arises from several factors, including their diverse therapeutic properties, safety profile, and cultural significance. Here's an in-depth look at why herbs are essential in wound healing:

### 1. Multifaceted Therapeutic Properties:

Herbs contain a plethora of bioactive compounds with diverse pharmacological activities, including antimicrobial, anti-inflammatory, antioxidant, and wound-healing effects. Unlike single-target synthetic drugs, herbs often exert their effects through multiple mechanisms, making them effective in addressing various aspects of the complex wound healing process. For example, herbs such as aloe vera, turmeric, and calendula possess antibacterial properties to prevent infections, anti-inflammatory effects to reduce swelling and pain, and wound-repairing properties to promote tissue regeneration.

### 2. Broad-Spectrum Antimicrobial Activity:

One of the primary challenges in wound healing is the risk of infection, which can significantly delay the healing process and lead to complications. Many herbs exhibit broad-spectrum antimicrobial activity against bacteria, fungi, and other pathogens commonly found in wounds. For instance, garlic, thyme, and tea tree oil have demonstrated potent antibacterial and antifungal properties, making them effective natural alternatives to conventional antimicrobial agents.

### 3. Promotion of Tissue Regeneration:

Herbal remedies can stimulate various stages of the wound healing process, including inflammation, proliferation, and remodeling. Some herbs contain bioactive compounds that promote the growth of new blood vessels (angiogenesis), accelerate the formation of granulation tissue, and enhance the synthesis of extracellular matrix components such as collagen. These effects contribute to faster wound closure, improved tensile strength, and reduced scar formation, ultimately restoring the integrity and function of the injured tissue.

### 4. Anti-inflammatory Effects:

Chronic inflammation is a common barrier to successful wound healing, characterized by excessive production of pro-inflammatory cytokines and prolonged tissue damage. Many herbs possess potent anti-inflammatory properties, helping to modulate the inflammatory response and create a favorable environment for tissue repair. For example, compounds like curcumin in turmeric and boswellic acids in frankincense inhibit inflammatory mediators such as cyclooxygenase and lipoxygenase enzymes, thereby reducing pain, swelling, and redness associated with wounds.

### 5. Safety and Minimal Side Effects:

Herbal remedies are generally well-tolerated and associated with fewer side effects compared to synthetic drugs. This is attributed to their natural origins and long history of traditional use, which provides reassurance of their safety profile. While allergic reactions or adverse effects can still occur, they are relatively rare and typically milder in nature. Additionally, herbs offer a gentler alternative for individuals with sensitive skin or underlying health conditions that may preclude the use of certain medications.

### 6. Cultural and Traditional Significance:

Herbs have been integral to traditional healing practices in diverse cultures around the world for centuries. Indigenous knowledge systems have identified and utilized local plant species for treating wounds and injuries, passing down this valuable wisdom through generations. Incorporating

culturally relevant herbs into wound care not only respects traditional healing practices but also fosters a sense of cultural continuity and community empowerment. Furthermore, indigenous peoples often possess unique insights into the medicinal properties and sustainable harvesting practices of local plants, which can inform evidence-based approaches to herbal medicine.

#### 7. Cost-Effectiveness and Accessibility:

Herbal remedies are often more affordable and accessible than pharmaceutical drugs, particularly in resource-limited settings where healthcare resources may be scarce. Many medicinal plants can be cultivated locally or harvested from the wild, reducing reliance on expensive imported medications. Additionally, herbal preparations can be easily prepared at home or obtained from local markets, making them accessible to individuals who may not have access to modern healthcare facilities. By leveraging existing knowledge and resources within communities, herbal medicine can address the healthcare needs of underserved populations and promote health equity.

In conclusion, herbs play a crucial role in wound healing by harnessing their diverse therapeutic properties, safety profile, cultural significance, and accessibility. Integrating herbal remedies into wound care protocols offers a holistic approach to healing that addresses the multifaceted nature of wounds and promotes optimal recovery. However, further research is needed to validate the efficacy, safety, and mechanisms of action of specific herbs in wound healing, and to integrate herbal medicine into evidence-based healthcare practices.[8]

### Traditional use of medicinal plants in wound healing

Egyptians, as well as native populations in Africa, Asia, the Americas, and Rome, used medicinal plants for over 5,000 years as a first-line treatment for burns, ulcers, inflammation, and surgical wounds. They include a variety of naturally occurring bioactive substances that promote wound healing more quickly and promote tissue regeneration at the site of the wound.

Certainly Here are some key herbal ingredients commonly used in wound healing creams, long with their properties and mechanisms of action.[21]

#### 1.Aloe Vera:

Aloe vera gel, sourced from the leaves of the Aloe vera plant, is renowned for its remarkable wound healing attributes. Bursting with polysaccharides, vitamins, minerals, and amino acids, it serves as a potent aid in tissue regeneration, inflammation reduction, and collagen synthesis enhancement. Aloe vera's antimicrobial properties further fortify its role by thwarting infections and expediting the wound healing process.



Fig:3 Aloe Vera

#### Taxonomical characteristic:

**Kingdom:** Plantae  
**Division:** Magnoliophyta (Angiosperms)  
**Class:** Liliopsida  
**Order:** Asparagales  
**Family:** Asphodelaceae (formerly Aloaceae)  
**Genus:** Aloe  
**Species:** Aloe vera.[12]

#### Chemical Constituents of Aloe Vera:

Components	Alleged pharmacological activities
Barbaloin	Polysaccharide
Aloe-Emodin, emodin	Purgative, cell proliferation, anticancer, antiprotozoal, antibacterial

Mannose-6- Phosphate	Wound healing
Aloesin	Inhibition of melanin synthesis
B-Sitosterol	Antiinflammation, angiogenesis
Polysaccharide	Immunomodulation [13]

### Pharmacological Activities:

- Anti-inflammatory properties:** Aloe vera contains compounds such as acemannan, lupeol, and salicylic acid, which possess anti-inflammatory properties. By reducing inflammation at the wound site, aloe vera may help alleviate pain and promote a more conducive environment for healing.
- Antimicrobial activity:** Aloe vera exhibits antimicrobial properties against a wide range of bacteria, fungi, and viruses. By inhibiting the growth of pathogens, aloe vera may help prevent wound infections and facilitate the healing process.
- Promotion of collagen synthesis:** Aloe vera contains various compounds that stimulate the production of collagen, a key protein involved in wound healing. Collagen provides structural support to the wound and helps promote tissue regeneration and remodeling.
- Moisture retention:** Aloe vera gel has a high water content and forms a protective barrier over the wound, helping to retain moisture and prevent excessive drying. Maintaining a moist environment is important for optimal wound healing as it facilitates cell migration, proliferation, and tissue repair.
- Antioxidant activity:** Aloe vera contains antioxidants such as vitamins C and E, as well as polyphenols and flavonoids, which help neutralize harmful free radicals and reduce oxidative stress at the wound site. By protecting cells from oxidative damage, aloe vera may support the healing process and minimize tissue damage.
- Enhanced angiogenesis:** Some studies suggest that aloe vera may promote angiogenesis, the formation of new blood vessels, in the vicinity of the wound. Improved blood flow to the wound site can increase oxygen and nutrient delivery, facilitating tissue repair and regeneration.
- Pain relief:** Aloe vera gel has a cooling and soothing effect on the skin, which can help alleviate pain and discomfort associated with wounds, burns, and other skin injuries.

### *Aloe vera can be incorporated into various formulations for wound healing, including*

- 1.Topical Gel:** Aloe vera gel is perhaps the most common formulation used for wound healing. It can be applied directly to the wound or incorporated into commercial wound care products such as gels, creams, or ointments. The gel provides a protective barrier over the wound, helps retain moisture, and delivers beneficial compounds to promote healing.
- 2. Hydrogel Dressings:** Hydrogel dressings are a type of wound dressing that contains high water content, similar to aloe vera gel. Aloe vera can be added to hydrogel formulations to enhance their properties, such as moisture retention, cooling effect, and potential wound healing benefits.
- 3.Sprays and Aerosols:** Aloe vera extracts can be formulated into sprays or aerosols for easy application to wounds. These formulations may provide cooling and soothing effects while delivering beneficial compounds to the wound site.
- 4. Creams and Lotions:** Aloe vera can be incorporated into creams or lotions designed for wound healing. These formulations may contain additional ingredients such as moisturizers, emollients, and antimicrobial agents to further support the healing process.
- 5.Wound Healing Films:** Aloe vera can be incorporated into thin, transparent films or membranes that adhere to the skin to create a protective barrier over the wound. These films may contain aloe vera along with other bioactive compounds to promote wound healing.
- 6. Wound Cleansers:** Aloe vera can be included in wound cleansing solutions or sprays used to clean and debride wounds. Its antimicrobial properties may help reduce the risk of infection during the wound healing process.
- 7. Impregnated Dressings:** Aloe vera can be impregnated into various types of wound dressings, such as gauze, foam, or non-adherent dressings. These dressings release aloe vera slowly onto the wound site, providing sustained benefits for wound healing.[11]

### 2. Calendula:

Calendula officinalis, also known as marigold, is rich in flavonoids, carotenoids, and triterpene saponins, which exhibit anti-inflammatory, antimicrobial, and antioxidant effects. Calendula extracts stimulate granulation tissue formation, enhance wound contraction, and promote epithelialization. They also help to soothe irritated skin and reduce pain associated with wounds.



**Fig.4 Calendula officinalis**

**Taxonomical characteristic:**

**Kingdom:** Plantae  
**Phylum:** Angiosperms  
**Class:** Eudicots  
**Order:** Asterales  
**Family :** Asteraceae (Compositae)  
**Genus:** Calendula  
**Species:** Calendula officinalis [14]

**Chemical Constituents of Calendula officinalis:**

Phytochemical Constituent	Pharmacological Activity
Quinones	Anti-cancer
Carbohydrates	Anti-inflammatory Immunostimulant
Flavonoids	Antioxidant Anti-inflammatory Hepatoprotective
Coumarins	Antioxidant Anti-inflammatory Anti-cancer
Terpenoids	Cardioprotective Anti-diabetic Anti-inflammatory Anti-tumor
Amino acids	Anti-cancer
Volatile oils	Antioxidant
Carotenoids	Antioxidant Anti-cancer Spasmolytic Anti-helminthic Wound healing [15]

**Pharmacological Activities:**

- 1. Anti-inflammatory properties:** Calendula contains flavonoids, triterpenoids, and other compounds that have anti-inflammatory effects. These properties help reduce inflammation at the site of the wound, which can alleviate pain and promote healing.
- 2. Antimicrobial activity:** Calendula possesses antimicrobial properties, which help prevent infection in wounds. By inhibiting the growth of bacteria, fungi, and other microorganisms, calendula extracts create an environment conducive to wound healing.

3. **3.Promotes tissue regeneration:** Calendula extracts stimulate the production of collagen, a protein essential for wound healing and tissue regeneration. This helps accelerate the formation of new skin cells and minimizes scarring.
4. **4.Antioxidant effects:** Calendula is rich in antioxidants, such as flavonoids and carotenoids, which protect cells from oxidative stress and damage. By neutralizing free radicals, calendula supports the body's natural healing processes and aids in tissue repair.
5. **5.Analgesic properties:** Calendula can provide mild analgesic effects, helping to alleviate pain and discomfort associated with wounds and injuries.
6. **Moisture retention:** Calendula-based preparations often form a protective barrier over wounds, helping to retain moisture and prevent excessive drying. This promotes an optimal environment for wound healing.
7. **Gentle on the skin:** Calendula is generally well-tolerated by most individuals and is considered safe for topical use, even on sensitive skin. Its mild nature makes it suitable for a wide range of wounds, including minor cuts, scrapes, burns, and abrasions. [9]

**3.Turmeric:**

Curcuma species are widely used as a food additive and also in various medicinal purposes. The plant is a rich source of essential oil and is predominantly extracted from the rhizomes.

Curcuma longa, or turmeric, contains curcumin, a polyphenolic compound with antioxidant, anti-inflammatory, and antimicrobial properties. Turmeric extracts accelerate wound healing by reducing inflammation, enhancing collagen synthesis, and promoting angiogenesis. Curcumin also inhibits bacterial growth and biofilm formation, reducing the risk of wound infections.[16]



**Fig.5 Termeric**

**Taxonomical characteristic:**

- Kingdom:** Plantae
- Subkingdom:** Tracheobionta
- Superdivision:** Spermatophyta
- Division:** Magnoliophyta
- Subclass:** Zingiberidae
- Order:** Zingiberales
- Family:** Zingiberaceae
- Genus:** Curcuma
- Species:** longa
- Scientific name:** Curcuma longa [17]

**Chemical Constituents of Turmeric:**

Phytochemical Constituent	Pharmacological Activity
Curcumin	Anti-inflammatory, Antioxidant Anti-tumor and anti-cancer, Anti-Hiv Anti-fungal, Antifibrinogenic, Wound healing.
Demethoxycurcumin	Antioxidant
Bisdemethoxycurcumin	Antioxidant
Triethyl curcumin	Anti-inflammatory



Tetrahydrocurcumin	Anti-inflammatory
Turmeric oil	Anti-bacterial, anti-fungal
Ethanol extract	Anti-protozoa Anti-fungal
Acetone extract	Anti-fungal Antioxidant [18]

#### Pharmacological Activities:

**1. Anti-inflammatory Properties:** Curcumin has potent anti-inflammatory effects. Inflammation plays a crucial role in the initial stages of wound healing. By reducing inflammation, curcumin can help control excessive immune response and facilitate the healing process.

**2. Antioxidant Activity:** Curcumin is a strong antioxidant that scavenges free radicals. Oxidative stress can impair wound healing by damaging cells and tissues. Curcumin's antioxidant properties help protect cells from oxidative damage and support tissue repair.

**3. Promotion of Collagen Synthesis:** Collagen is a key structural protein in wound healing. Curcumin stimulates collagen synthesis, which is essential for strengthening the wound and promoting tissue regeneration.

**4. Antimicrobial Effects:** Turmeric has natural antimicrobial properties that can help prevent wound infections. Curcumin exhibits antibacterial and antifungal activity against various pathogens commonly associated with wound infections.[19]

**5. Enhanced Angiogenesis:** Angiogenesis, the formation of new blood vessels, is crucial for delivering oxygen and nutrients to the wound site. Curcumin promotes angiogenesis, thereby facilitating faster wound healing.

**6. Modulation of Growth Factors:** Curcumin can influence the expression and activity of growth factors involved in wound healing, such as transforming growth factor-beta (TGF-beta) and vascular endothelial growth factor (VEGF). These growth factors play key roles in tissue repair and regeneration.

**7. Pain Relief:** Turmeric possesses analgesic properties that can help alleviate pain associated with wounds, promoting a more comfortable healing process.

**8. Scar Reduction:** Curcumin has been shown to inhibit excessive scar formation (hypertrophic scarring) by modulating collagen production and deposition.

#### 4. *Neem (Azadirachta indica)*

Neem (*Azadirachta Indica*) is a well-known medicinal plant with a broad range of biological activity used in homoeopathic and traditional medicine as a home remedy for a variety of human ailments.

Recent studies and research show that neem contains many therapeutic effects such as anti-inflammatory, anti-diabetic, antifungal, antiviral, antibacterial, and anti-malarial. Neem contains many active ingredients such as nimbidin, nimbin, and nimbidol with anti-inflammatory, antibacterial, antifungal and antiviral properties that may help it accelerating the wound healing process.[22]



**Fig.6 Neem**

#### Taxonomical characteristic:

**Scientific Name:** *Azadirachta*

**Family:** Meliaceae

**Subfamily:** Melioideae

**Genus:** *Azadirachta*; A.Juss.

**Kingdom:** Plantae

**Order:** Sapindale [23]

**Chemical Constituents of Neem:**

Phytochemical Constituent	Pharmacological Activity
Nimbidin	Anti-inflammatory, Anti-arthritis, Hypoglycemic, Antipyretic, Spermicidal, Antifungal, Antibacterial, Diuretic.
Azadirachtin	Antimalarial
Nimbin	Mahmoodin
Gallic Acid and Catechin	Antibacterial
Polysaccharides G2A	Anti-inflammatory [24]

**Pharmacological activity****1. Antimicrobial Properties:**

Azadirachtin and Nimbidin: Neem contains these compounds, which exhibit strong antibacterial, antifungal, and antiviral properties. They help prevent infections in wounds, promoting faster healing.

**2. Anti-inflammatory Activity:**

Nimbin and Quercetin: These compounds reduce inflammation by inhibiting the release of pro-inflammatory cytokines and enzymes like cyclooxygenase and lipoxygenase, thereby reducing pain and swelling associated with wounds.

**3. Antioxidant Effects:**

Flavonoids and Polyphenols: Neem leaves and oil are rich in antioxidants that scavenge free radicals. This activity protects the wound area from oxidative stress, facilitating the healing process.

**4. Wound Contraction and Epithelialization:**

Tannins and Glycosides: These compounds aid in wound contraction and promote the formation of new epithelial tissue. This speeds up the wound closure process.

**5. Collagen Synthesis:**

Glycosides and Tannins: Neem extracts have been shown to enhance collagen production, a crucial part of the wound healing process as collagen provides the necessary structural framework for new tissue formation.[26]

**Marketed Herbal Wound Healing Formulation****1. Himalaya Herbals Antiseptic Cream**

- Ingredients: Neem, turmeric, aloe vera
- Uses: Cuts, wounds, burns, skin infections

**Fig.7 Himalaya Herbals Antiseptic Cream****2. Vicco Turmeric Skin Cream**

- Ingredients: Turmeric, potentially includes aloe vera
- Uses: Antiseptic, skin healing



**Fig.8 Vicco Turmeric Skin Cream**

### 3. Savlon Antiseptic Cream

- Ingredients: Aloe vera, other antiseptic ingredients
- Uses: Minor wounds, skin irritations



**Fig.9 Savlon Antiseptic Cream**

### 4. Weleda Calendula Wound Healing Cream

- Ingredients: Calendula officinalis, potentially includes aloe vera
- Uses: Wound healing, skin care



**Fig.10Weleda Calendula Wound Healing Cream**

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### Conclusion :

This Report has provided a comprehensive overview of the mechanism of wound healing, the anatomy of the skin, and the utilization of herbal remedies in wound healing preparations. Wound healing is a complex and dynamic process involving a series of well-coordinated cellular and molecular events aimed at restoring tissue integrity and function following injury.

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