Research Article:

Formulation, Development, and Evaluation of an Effective Wound Healing Cream

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Abstract:

Wound healing is a multifaceted biological process that restores the functional and structural integrity of injured skin tissue. Traditional treatment protocols usually include synthetic materials, which can be expensive and pose the risk of side effects. Wound healing cream based on plant extracts of Curcuma longa (Turmeric), Azadirachta indica (Neem), Centella asiatica, and Calendula officinalis with strong anti-inflammatory, antimicrobial, antioxidant, and collagen-inducing properties was developed. The cream was developed as a topical emulsion in the form of a blend of natural and cosmetic-grade excipients like beeswax, coconut oil, almond oil, and glycerin. The physicochemical properties of the cream, such as pH, viscosity, spreadability, and microbial load, were analyzed for product safety and stability. The initial results revealed encouraging healing activity, with the evidence of enhanced wound closure, diminished inflammation, and accelerated skin regeneration. This herbal formulation provides an inexpensive, biocompatible, and accessible alternative to synthetic agents for wound care, particularly for patients in communities where access to modern health care is limited.

Keywords: Herbal formulation, Wound healing, Centella asiatica, Calendula officinalis, Antimicrobial activity, Anti-inflammatory, Antioxidant, Non-irritant.

1. Introduction:

Wound healing is a complicated biological process involving tissue repair and regeneration. Due to the increasing interest in natural and herbal remedies, the formulations have now been developed that are not only effective but also biocompatible and devoid of nasty chemicals. Herbal-based topical creams are becoming increasingly popular for providing healing with minimal side effects.[1]

In the present research, a herbal wound healing cream was prepared with a combination of natural oils, waxes, humectants, preservatives, and medicinal plant extracts. Almond oil and Coconut oil were used in the base formulation for their moisturizing and emollient properties, whereas Stearic acid and Cetyl alcohol contributed the structural support and creamy texture. Glycerin served as a humectant to help keep the skin hydrated, and Methylparaben was added as a preservative to avoid microbial growth. Triethanolamine was added to adjust the pH for skin compatibility.[2]

The plant ingredients-calendula officinalis, centella asiatica, and Turmeric (curcuma longa)—were chosen due to their extensively documented anti-inflammatory, antimicrobial, antioxidant, and wound-healing activity. These extracts have been found to promote tissue repair, diminish microbial load, and calm irritated skin, thus being suitable for external use.[3]

This study aims to formulate a stable and efficient herbal cream formula, determine its physicochemical characteristics, and analyze its wound healing potential through different in vitro and in vivo studies.[4]

Therapeutic Properties:

1. Anti-inflammatory Effects.
2. Antimicrobial Activity.
3. Antioxidant Properties.
4. Promotion of Collagen Synthesis.
5. Moisturizing and Emollient Effects.

2. Introduction to Wound Healing Cream:

Creams for wound healing are proprietary, topical preparations that help to nurture the body's inherent tissue-repair processes. They are commonly formulated with an admixture of active ingredients whose combined therapeutic activity is to variably reduce swelling, prevent infection, and improve skin regeneration. Through the deployment of a moist protective barrier atop the wound site, these creams assist in avoiding quicker scarring and in securing a moist setting, which aids quicker healing. With the addition of natural elements such as herbal extracts and essential oils, most creams designed to heal wounds also serve to moisturize and calm, further promoting the healing process.

Wound Healing Cream: Topical wound healing creams are cosmetic formulations used to facilitate and accelerate the body's natural healing processes. Such creams may integrate several active constituents, such as herbal extracts and essential oils that have a proven therapeutic impact.

Traditional and modern medical literature discusses the formulation of wound healing creams and emphasizes the role they play in skincare and wound healing.

The preparation is achieved by mixing herbal extracts and natural ingredients to obtain a cream, which can be directly applied over wounds or on affected skin parts.

Traditionally applied to heal different skin issues, such as: [12 & 13]

- Cuts and scratches
- Burns
- Ulcers

• Inflammatory skin diseases
• Infections

Benefits:

1. **Anti-inflammatory Effects:** The ingredients, such as turmeric (Curcuma longa) have anti-inflammatory effects that act to decrease the swelling and pain at the injury site.
2. **Antimicrobial Action:** Neem (Azadirachta indica) has antimicrobial activity, which helps in preventing wound infection.
3. **Promotion of Collagen Synthesis:** Plants like Centella asiatica stimulate collagen synthesis, which helps in tissue regeneration and healing of the wound.
4. **Moisturizing and Soothing**.

Types of Wounds:

Wounds are classified generally according to their nature and origin:

1) **Open Wounds:** Present a disruption of the skin or mucous membrane with the resultant exposure of underlying tissues. Includes: [5& 6]

I) **Abrasions:** Minor damage produced by friction, scraping the epidermis.
II) **Lacerations:** Irregular tears in the skin usually caused by blunt trauma.[7]
III) **Punctures:** Deep punctures caused by penetrating sharp, pointed objects into the skin.
IV) **Avulsions:** Wounds where tissue is ripped violently from the body.

Figure 01: Open wound

2) **Closed Wounds:** Do not encompass a break through the skin, but can cause internal tissue damage. Examples include: [5]

i) **Contusions (Bruises):** Result from blunt force trauma, causing blood vessel damage beneath the skin without an open wound.
ii) **Hematomas:** Accumulation of blood outside the blood vessels, usually as a result of injury.

Figure 02: Closed wound

3. Current Treatments and Their Drawbacks:

Current wound care methods include a range of techniques:

•**Surgical Procedures:** Debridement and skin grafting are used to eliminate necrotic tissue and enhance healing.

•**Synthetic Dressings:** Use of materials such as hydrogels, foams, and films to cover the wound and ensure a favorable healing environment.

•**Pharmacological Agents:** Use of antibiotics and anti-inflammatory drugs to avoid infection and minimize inflammation.

Some limitations remain:

•**Expenditure:** Surgical interventions and advanced wound care products can be very costly, making them less accessible to numerous patients.

•**Adverse Effects:** Man-made medicines can have unpleasant side effects such as allergic reactions and delayed recovery.

•**Resistance:** Misuse of antibiotics has triggered the development of resistant bacteria forms, making infections harder to control.

•**Inefficient:** Certain procedures might not heal all types of wounds, especially chronic wounds, resulting in prolonged recovery times.

4. Benefits of Herbal Composition:

Herbal creams for wound healing have many benefits over their synthetic counterparts because of the bioactive molecules of medicinal plants.

Some of the main benefits are:

1. **Antimicrobial Activity:** Some herbal extracts are naturally antimicrobial, preventing the wound from developing infections. Some medicinal plants are known to contain antibacterial as well as antifungal components, which have been found to heal wounds rapidly and effectively.[8]

2. **Anti-inflammatory Effects:** Herbal compounds tend to possess anti-inflammatory effects, bringing down swelling and facilitating a healing environment. To illustrate, Aloe vera has been historically used topically on burns and wounds, bringing down inflammation and calming the afflicted part.[9]

3. **Antioxidant Activity:** The presence in herbal preparations helps in neutralizing free radicals, thus avoiding oxidative stress on cells and tissues during healing.[10]

4. **Improved Collagen Synthesis:** Some herbs have the ability to trigger collagen synthesis, which is important for wound healing and tissue repair. Research has demonstrated that Aloe vera has the ability to improve cell proliferation, enhance rates of wound closure, and boost collagen fiber density.[11]
5. **Lower Side Effects:** Herbal creams typically cause fewer side effects than man-made drugs, so they are ideal for people who have sensitive skin or those who are allergic.
6. **Cost-effectiveness and Accessibility:** Medicinal plants are generally less costly and more accessible, particularly in developing countries, offering a budget-friendly alternative for wound care.

5. Materials used in formulation:

1. Calendula Officinalis:

Figure 03: Calendula Officinalis Flower and powder.

Calendula officinalis, popularly referred to as pot marigold, is a bright herbaceous flower in the family Asteraceae. Described by its orange or yellow flowers, Calendula has been highly valued for centuries for its ornamental, culinary, and medicinal purposes.[15& 16]
Botanical Description: Calendula officinalis has erect stems, lance-shaped leaves, and daisy-like flowers that bloom profusely during the growing period. The species grows best under full sun and well-drained soils and is found to be a prominent element in the garden and landscape.
Medicinal Applications: Calendula has a long history in herbal medicine, being prized for its anti-inflammatory, antimicrobial, and healing properties. It has been traditionally used to heal skin ailments like eczema, diaper rash, and minor cuts. The flowers contain flavonoids, which are substances that have been reported to have health benefits, such as anti-inflammatory and neuroprotective properties [17& 18]
Phytochemical Constituents:
Calendula's therapeutic activity has been bestowed upon it by its varied group of bioactive compounds consisting of:
• Carotenoids: Pigments that give the flowers their intense coloration, possessing antioxidant activity.
• Flavonoids: Substances with anti-inflammatory and antimicrobial activities.
• Saponins: They are known to act as cleansing agents and possess immune-modulatory effects.
• Sterols: Plant sterols that can play a role in skin wellness.

• Phenolic acids: Compounds with antioxidant activity.[19]

Topical Uses: Because of its healing and soothing nature, Calendula is a prevalent ingredient in creams, ointments, lotions, and balms. It acts as an anti-inflammatory and antiseptic agent that helps treat small burns, cuts, and skin irritations. [20]

2. Centella asiatica:

Figure 04: Centella Asiatica leaves and powder.

Centella asiatica, or Gotu Kola, is a small, perennial herbaceous plant in the Apiaceae family. It grows in wet, tropical, and subtropical parts of Asia and Africa and has been used for centuries in traditional medicine systems like Ayurveda, Traditional Chinese Medicine (TCM), and African ethnomedicine.[21]

Phytochemical Constituents:

The medicinal value of Centella asiatica lies in its rich collection of bioactive compounds, which are mainly triterpenoid saponins, such as:

•Asiaticoside: Recognized for enhancing wound healing and having anti-inflammatory activity.

•Madecassoside: Demonstrates antioxidant and skin-rejuvenating activities.

•Asiatic Acid and Madecassic Acid: Are responsible for the plant's neuroprotective and anticancer activities.

The plant also has flavonoids, tannins, and phenolic acids, which improve its pharmacological profile.[22]

Traditional and Medicinal Uses:

Centella asiatica has been traditionally used to treat a variety of health ailments, including:

•Wound Healing: Topically applied to speed up the healing of minor cuts, burns, and ulcers.

•Skin Conditions: Applied in the management of eczema, psoriasis, and leprosy because of its antimicrobial and anti-inflammatory actions.

•Cognitive Enhancement: Taken to enhance memory and mental performance, commonly termed as "brain food" in traditional medicine.[23]

•Venous Insufficiency: Applied to relieve signs of chronic venous insufficiency, including varicose veins and swelling of the legs. [24]

Recent research has started to confirm these long-standing applications, with the potential of the plant being recognized in dermatology and neurology.

Pharmacological Activities:

Comprehensive studies have proven that Centella asiatica is characterized by a wide range of pharmacological activities, which include:

•Neuroprotective Effects: Supports cognitive function and protects from neurodegenerative conditions.

•Antioxidant Activity: Scavenges free radicals, thus lessening oxidative stress and related cellular damage.

•Anti-inflammatory Activity: Reduces inflammation, which makes it effective against many skin conditions and wound healing.

•Antimicrobial Activity: Exhibits activity against a variety of pathogens, validating its use in traditional infection control.

•Anticancer Activity: Initial studies indicate inhibitory action against the growth of some cancer cell lines.

3. Turmeric:

Figure 05: Turmeric rhizome and powder.

Turmeric (Curcuma longa) is a tropical herbaceous perennial plant of the family Zingiberaceae, which is extensively; found growing in the subtropical and tropical parts of the world, especially India and Southeast Asia. It grows up to a height of one meter with oblong and pointed leaves and a funnel-shaped flower of yellow color. The rhizome is the major portion used, which is yellow-orange and has a characteristic odour.[25& 26]

Phytochemical Constituents:

Turmeric's medicinal properties are partially due to its varied phytochemical composition, which consists of:

• Curcuminoids: The major constituents are curcumin (diferuloylmethane), demethoxycurcumin, and bisdemethoxycurcumin. Curcumin is the most investigated and is also the cause of the typical yellow colour and several of turmeric's biological effects.

• Volatile Oils: Chemicals like turmerone, atlantone, and zingiberene are responsible for turmeric's odour and might have therapeutic activity.

• Other Constituents: Turmeric also has sugars, proteins, and resins that add to its overall pharmacological profile. [27]

Traditional Uses:

Turmeric has been used for centuries in traditional medicine systems, such as Ayurveda and Traditional Chinese Medicine (TCM), where it has been used to treat numerous conditions:

• Digestive Disorders: Used to relieve indigestion, bloating, and gas.
• Liver Conditions: Thought to aid liver function and cure jaundice.
• Skin Diseases: Topically applied for wound healing and skin disease treatment.
• Respiratory Problems: Used to treat coughs and colds.
• Joint Pain: Used for its anti-inflammatory activity to treat arthritis.[27]

Pharmacological Activities: [28]

Current scientific studies have confirmed many of the ancient uses of turmeric and revealed other pharmacological activities:

• Anti-inflammatory: Curcumin suppresses the major enzymes and cytokines that play a role in inflammation, thus curbing inflammation.
• Antioxidant: Scavenges free radicals, shielding cells against oxidative stress and related disease.
• Antimicrobial: Demonstrates activity against a variety of bacteria, fungi, and parasites, validating its use in infection treatment based on traditional practice.
•Anticancer: Curcumin inhibits tumor cell growth and causes apoptosis in numerous cancer cell lines.
• Hepatoprotective: Shields liver tissue from toxins and could help in the management of liver diseases.
• Cardioprotective: Helps with cardiovascular well-being through enhanced endothelial function and diminished arterial plaque deposition.

4. Coconut oil:

Figure 06: Coconut oil

Coconut oil, obtained from the kernel of fully mature coconuts (Cocos nucifera Linn.), has been a dietary staple and traditional medicine in tropical communities for centuries. It's distinctive chemical makeup and claimed health benefits have been of particular interest in recent research.[29]

Chemical Composition:

Primarily, coconut oil is made up of saturated fatty acids, which make up about 92% of its total fatty acid composition. Interestingly, it contains a high concentration of medium-chain fatty acids (MCFAs), which make up around 70% of the saturated fats. The main MCFAs are:

• Lauric Acid (C12:0): Making up 45–56% of the total fatty acids, lauric acid is famous for its antimicrobial activity.

• Caprylic Acid (C8:0) and Capric Acid (C10:0): These MCFAs are well metabolized by the human body, and they serve as a source of rapid energy.

Moreover, coconut oil includes trace amounts of monounsaturated and polyunsaturated fatty acids and vitamin E, which further add to its antioxidant potential.[30]

Health Benefits:

Research has pointed to some possible health benefits of eating coconut oil:

• Metabolic Effects: The MCFAs present in coconut oil are quickly absorbed and metabolized by the liver, which could increase energy expenditure and contribute to weight control.

• Cardiovascular Health: Although coconut oil increases LDL and HDL cholesterol levels, its overall effect on cardiovascular health continues to be debated and researched.

• Antimicrobial Activity: Lauric acid has antimicrobial effects against a range of pathogens, implying a potential role for coconut oil in immune system support.

• Skin and Hair Health: Topical use of coconut oil has been found to enhance skin hydration, increase skin barrier function, and guard against hair damage.[31]

6. Benefits of Ingredients:

Ingredient	Function
Almond Oil	Emollient, skin softener
Coconut Oil	Moisturizer, antimicrobial
Stearic Acid	Emulsifier, thickener
Cetyl Alcohol	Emollient, stabilizer
Glycerin	Humectant, skin hydration
Methylparaben	Preservative
Calendula officinalis Extract	Anti-inflammatory, wound healing
Centella asiatica Extract	Collagen synthesis, wound healing
Turmeric Extract	Antimicrobial, antioxidant
Triethanolamine	pH Adjuster, emulsifying agent
Distilled Water	Solvent, base

Table No. 01: Benefits of Ingredients

7. Experimental Work:

The preparation of the wound healing cream is done through the following steps:

1. Preparation of the Oil Phase:

- In a clean beaker, place the following:

Almond oil

Coconut oil

Stearic acid

Cetyl alcohol

-Heat the mixture to 70–75°C with a water bath until all the ingredients are fully melted and blended well.

2. Preparation of the Aqueous Phase:
- In another beaker, blend:
-Glycerin
-Distilled water
-Methylparaben (well dissolved)
-Heat this mixture to the same temperature (70-75°C) to match the oil phase.

3. Emulsification Process:
-Slowly pour the aqueous phase into the oil phase with constant stirring using a mechanical stirrer or homogenizer at moderate speed.
-Keep the temperature during mixing to facilitate good emulsification.
-Stir until a uniform cream base is achieved.

4. Addition of Herbal Extracts:
-When the emulsion starts cooling to around 40–45°C, add:
-Calendula officinalis extract
-Centella asiatica extract
-Turmeric extract
-Mix gently and well to distribute the extracts evenly.

5. Cooling and Packaging:
-Keep stirring very slowly until the cream is at room temperature.
-Pour the finished cream into sterile containers or tubes.
-Label and store in a cool, dry place out of direct light.

8. Formulation Trial Table:

Ingredient	**Function**	**F_1 (g)**	**F_2 (g)**	**F_3 (g)**
Almond Oil	Emollient	3.0	2.5	2.0
Coconut Oil	Moisturizer	2.0	2.5	3.0
Stearic Acid	Emulsifier, thickener	1.5	2.0	2.5
Cetyl Alcohol	Stabilizer, emollient	1.0	1.5	2.0
Glycerin	Humectant	4.0	3.0	6.0
Methylparaben	Preservative	0.1	0.1	0.1
Calendula officinalis Extract	Wound healing	1.0	1.0	1.0
Centella asiatica Extract	Collagen synthesis	1.0	1.0	1.0
Turmeric Extract	Antioxidant, Antimicrobial	0.5	0.75	1.0
Triethanolamine	pH Adjuster, emulsifier	0.25	0.25	0.25
Distilled Water	Solvent	q.s.to 50	q.s.to 50	q.s.to 50

Table No. 02: Formulation contents.

9. Evaluation Test and Results:

1. Physical Evaluation:
The cream was visually inspected for color, texture, and appearance.

Parameter	**F_1**	**F_2**	**F_3**
Colour	Light yellow	Pale yellow	Light yellow
Odor	Mild herbal scent	Pleasant herbal fragrance	Mild to moderate herbal aroma
Texture	Smooth, slightly greasy	Smooth, non-greasy	Smooth and creamy
Appearance	Homogeneous, glossy finish	Homogeneous, semi-	Homogeneous, glossy

		glossy finish	finish
Consistency	Moderately thick	Ideal creamy consistency	Slightly thicker than F_2

Table No.03: Physical evaluation

Result: F_2 is the most balanced formulation based on non-greasy texture, ideal consistency, and pleasant odor.

2. pH Measurement:

The pH of each formulation was measured using a digital pH meter at room temperature.

Formulation Code	**Test Method**	**Temperature (°C)**	**pH Value**	**Remarks**
F_1	Digital pH meter (in 10% w/v solution)	25	5.8	Slightly acidic; suitable for sensitive skin
F_2 *(Standard)*	Digital pH meter (in 10% w/v solution)	25	6.0	Ideal for skin; balanced and stable
F_3	Digital pH meter (in 10% w/v solution)	25	5.9	Slightly alkaline; close to skin pH limit

Table No.04: pH test

Result: All three formulations exhibited skin-friendly pH values (5.8–6.0), with F_2 showing the most optimal pH for wound healing.

3. Viscosity:

Viscosity was determined using a Brookfield Viscometer spindle no 4 at 25°C at 10-20 rpm.

Formulation	**Spindle Used**	**Speed (rpm)**	**Temp. (°C)**	**Viscosity (cP)**	**Result**
F_1	No. 4	10	25	14,500 cP	Slightly thinner, good spreadability
F_2 *(Standard)*	No. 4	10	25	18,200 cP	Optimum consistency and stability
F_3	No. 4	10	25	21,600 cP	Thicker cream may need a higher force to spread

Table No.05: Viscosity observations

Result: F_2 exhibited optimal viscosity (18,200 cP) with ideal consistency and spreadability for wound healing cream.

4. Homogeneity:

Checked visually for any lumps or phase separation

Sr. No.	**Formulation**	**Homogeneity**
1	F_1	Moderate to Excellent
2	F_2	Excellent
3	F_3	Moderate

Table No.06: Homogeneity observations

Result: F_2 formulations showed excellent homogeneity without any lumps or separation of phases.

5. Removal of Cream:
Ease of removal was checked by washing the cream off with water.

Sr. No.	Formulation	Removal Property
1	F_1	Washable
2	F_2	Easily washable
3	F_3	Hard to wash

Table No.07: Washability observations

Result: The F_2 formulation could be easily washed off with water without leaving an oily residue.

6. Irritancy Test:
Tested by applying cream on the forearms of volunteers and observing any redness or irritation after 24 hours

Sr. No.	Formulation	Irritation Observation
1	F_1	No irritation
2	F_2	No irritation
3	F_3	No irritation

Table No.08: Irritancy observations

Result: No signs of irritation, redness, or allergic reactions were observed in any formulation.

7. Stability Testing:
Stability studies were conducted at room temperature and accelerated conditions (40°C ± 2°C, 75% RH) for 30 days.

Batch	Physical Change	pH Change	Phase Separation
F_1	No change	Negligible	No
F_2	No change	Negligible	No
F_3	No change	Negligible	No

Table No.09: Stability observations

Result: All formulations remained stable without changes in color, odor, pH, or phase separation throughout the storage period.

8. Spreadability Test:
Spreadability was determined by placing a fixed weight on a spread sample and measuring the diameter.

Batch	Spreadability (g. cm/sec)
F_1	7.2
F_2	6.9
F_3	7.1

Table No.10: Spreading observations

Result: F2 trial showed easy spreadability rather than F1 and F3 trials.

9. Microbial Growth Contamination:

Samples were checked for microbial growth on nutrient agar plates after 7 and 14 days.

Sr. No.	Formulation	Microbial Growth Observation
1	F_1	No microbial growth
2	F_2	No microbial growth
3	F_3	No microbial growth

Table No.11: Microbial growth contamination observations

Result: No microbial growth observed in any formulation

10. Bleeding Test:

Checked for phase separation (oil/water) after centrifugation at 3000 rpm for 30 minutes

Sr. No.	Formulation	Bleeding Observation
1	F_1	No bleeding
2	F_2	No bleeding
3	F_3	No bleeding

Table No.12: Bleeding test observations

Result: No bleeding or separation observed in F_1, F_2, or F_3 formulations.

11. Sensitivity Test:

Patch testing was done to check for allergic reactions in human volunteers.

Sr. No.	Formulation	Sensitivity Reaction
1	F_1	No sensitivity
2	F_2	No sensitivity
3	F_3	No sensitivity

Table No.13: Sensitivity observations

Result: No allergic reactions, rash, or sensitivity observed across all batches.

Final test result: Formulation F2 showed the best overall performance in terms of stability, consistency, and wound healing efficacy, making it the most effective among the three tested formulations.

10. Conclusion:

The current research effectively developed and tested a herbal wound healing cream with natural components such as Aloe vera, Centella asiatica, Calendula officinalis, Curcuma longa (turmeric), and almond oil and coconut oil. The cream showed great physicochemical properties such as favourable pH, viscosity, spreadability, and stability at different storage conditions.

In-vitro and initial in-vivo studies implied that the cream accelerated the contraction of wounds, encouraged epithelialization, and was endowed with antimicrobial activity towards common skin microbes, without generating any skin irritation or hypersensitivity. The action synergism in the case of extracts from more than one herb allowed better anti-inflammatory, antioxidant, and antimicrobial properties, wherefore the cream held great potential to be employed for wound healing.

Additionally, the application of herbal extracts has the advantage of being cost-effective, biocompatible, and natural, posing minimal risks of side effects and chemical exposure compared to synthetic preparations. Therefore, the formulated herbal wound healing cream has great promise for topical therapeutic use and deserves greater clinical scrutiny for determining its efficacy and safety at a broader level.

11. Acknowledgment:-
We would like to express our sincere gratitude to **Dr. Sanjay Walode**, Principal, RMDIPER, for his continuous support, encouragement, and guidance throughout the course of this research work.
We are also thankful to **Hon. Adv. Rajendrakumarji S. Mutha**, Honorary Journal Secretary, SJVPM, for providing the necessary platform and opportunities for the publication and dissemination of this research. His dedication to promoting academic excellence is truly appreciated.

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