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FORMULATION AND EVALUTION OF HERBAL GEL FOR THE WOUND HEALING

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Introduction

Wounds are physical injuries that result in a disruption of the normal integrity and function of the skin and underlying tissues (1). They may arise from mechanical trauma, burns, surgery, infections, or chronic conditions such as diabetes mellitus and vascular disorders(2). The process of wound healing is a complex and dynamic physiological response, involving a cascade of cellular and biochemical events that aim to restore tissue structure and function(3). Traditionally, wound management has relied heavily on conventional approaches such as suturing, dressings, and the use of synthetic antimicrobial agents(4). However, these treatments may sometimes be associated with undesirable side effects, delayed healing, microbial resistance, or allergic reactions. Consequently, there is growing interest in exploring safe, effective, and affordable alternatives derived from medicinal plants to support and accelerate wound healing.(5)

Herbal medicines have been used across civilizations for thousands of years as primary remedies to treat wounds and skin infections(6). Plants contain a diverse array of phytoconstituents including flavonoids, tannins, alkaloids, saponins, glycosides, and terpenoids(7), many of which possess antimicrobial, antioxidant, anti-inflammatory, and wound healing properties(8). These bioactive compounds act synergistically to promote collagen synthesis, enhance re-epithelialization, contract wound size, and protect against microbial invasion(9). Some well-documented herbal agents with wound healing potential include *Aloe vera*, *Centella asiatica*, *Curcuma longa* (turmeric), *Azadirachta indica* (neem), *Calendula officinalis*, and *Ocimum sanctum* (holy basil)(10). Incorporating such botanical extracts into topical dosage forms like gels offers promising advantages over conventional ointments or creams. Gels are semi-solid systems that provide a cooling effect, ease of application, and better release and penetration of active ingredients into the wound bed(11).

The formulation of herbal gels requires careful selection of appropriate gelling agents, humectants, preservatives, and other excipients to ensure stability, uniformity, and patient acceptability(12). Carbopol, sodium alginate, and hydroxypropyl methylcellulose (HPMC) are commonly used polymers that can create a smooth and consistent gel matrix capable of holding herbal extracts in place over the wound area(13). In addition, proper pH adjustment and rheological optimization are essential to maintain the integrity of phytoconstituents and to ensure desirable consistency and spreadability(14). Evaluation parameters such as pH, viscosity, spreadability, extrudability, (15)homogeneity, and in vitro drug release help ascertain the quality of the formulation(16). Furthermore, antimicrobial studies and wound healing assays on suitable models provide scientific evidence of the therapeutic potential of the prepared herbal gel(17).

The increasing prevalence of chronic wounds such as diabetic ulcers and pressure sores underscores the need for effective topical formulations that can accelerate healing while minimizing infection risk(18). Herbal gels represent a promising approach owing to their biocompatibility, lower risk of adverse reactions, and the capacity to deliver a combination of phytochemicals directly to the affected site(19). Moreover, the use of locally available medicinal plants aligns with principles of traditional knowledge, sustainability, and cost-effectiveness, especially in low-resource settings(20). Recent studies have demonstrated that herbal-based wound healing gels can significantly reduce the time required for wound contraction, enhance granulation tissue formation, and improve tensile strength of healed skin(21).

In this context, the present study aims to develop and evaluate an herbal gel formulation using selected plant extracts known for their wound healing activity(22). The formulation process involves optimizing the concentration of gelling agents and other excipients to obtain a stable and effective gel(23). Physicochemical properties of the gel will be systematically evaluated to ensure compliance with standard quality parameters(24). Additionally, antimicrobial activity will be assessed to confirm the ability of the herbal gel to inhibit common wound pathogens. Finally, wound healing efficacy will be investigated using suitable experimental models to validate the potential of the herbal gel in promoting faster and more effective healing compared to conventional treatments(25).

This work not only contributes to the scientific understanding of herbal gels as a novel topical dosage form but also supports the integration of traditional medicinal knowledge with modern pharmaceutical technology(26). By exploring and validating natural alternatives, the study aspires to develop safe, efficacious, and patient-friendly wound care solutions that can be adapted for broader clinical use.(27)

Quality aspects of Herbals

Herbal Medicine

Herbal medicine is the practice of using plants or plant-derived substances to prevent, treat, or manage diseases and promote overall health.
It involves the preparation and administration of extracts, powders, teas, oils, or topical formulations made from medicinal herbs.
These remedies contain bioactive compounds like alkaloids, flavonoids, tannins, and terpenoids that exert therapeutic effects.
Herbal medicine is a core component of many traditional systems of healing, such as Ayurveda, Traditional Chinese Medicine, and Unani.
Today, it is widely used as a natural alternative or complement to modern pharmaceutical treatments.(28)

The raw material

The raw material refers to the natural plant parts—such as leaves, roots, stems, bark, flowers, or seeds—used to prepare herbal medicines.
These materials are collected, cleaned, dried, and sometimes powdered before extraction of their active constituents.(29)
The quality, purity, and authenticity of raw materials are crucial for the safety and effectiveness of herbal formulations.

Herbal preparation

Herbal preparation refers to the process of making medicinal products from plant materials for therapeutic use.(30)
It involves cleaning, drying, grinding, extracting, or combining herbs to create forms like powders, extracts, teas, tinctures, ointments, or gels.
The preparation method is chosen to best preserve and deliver the active plant constituents.(31)

Quality in the context of herbal drugs

Quality in herbal drugs means the degree to which a product is pure, authentic, safe, and effective.
It involves proper identification of plant materials, absence of contaminants (like microbes, pesticides, or heavy metals), and consistent levels of active ingredients.(32)
Good quality ensures that the herbal drug delivers the intended therapeutic benefits without causing harm.
Quality control includes standard procedures for collection, processing, storage, and testing of herbal materials.
Maintaining quality is essential for consumer trust and regulatory approval of herbal medicines.(33)

Factors affecting its quality about herbs

1. *Plant Species and Variety:* Using the correct botanical species and chemotype is essential for consistent therapeutic properties.
2. *Cultivation Conditions:* Soil quality, climate, use of fertilizers, and agricultural practices influence the levels of active compounds.
3. *Harvesting Time and Method:* The stage of growth and how the plant is collected affect potency and purity.
4. *Post-Harvest Handling:* Drying, storage, and transport must be controlled to prevent contamination and degradation.
5. *Processing Techniques:* Methods of extraction, grinding, and formulation impact the final quality, safety, and effectiveness of herbal products.(34)

Its need for quality evaluation of herbal drugs

Quality evaluation of herbal drugs is essential to ensure their *safety, purity, and therapeutic effectiveness.*
It helps *prevent contamination, adulteration, and substitution* with inferior or harmful materials.
Proper evaluation maintains *consistent levels of active ingredients* for reliable medicinal action.(35)
It builds *consumer confidence and meets regulatory standards* for herbal products.
Overall, quality control protects public health and supports the *scientific credibility of herbal medicine.*

Herbs have its following characteristics

A. They are small plants with soft and delicatepetals.
B. They have a tender, soft, and delicate green exterior.
C. They have a short lifespan, which means they can only live one or two years.
D. They are shorter in size, and they may grow between 2 and 3 metres.

The Limitations of Herbal Medicine

1. There are constraints related to how medicinal plants are cared for, including **uncontrolled harvesting practices and poor post-harvest**

handling.

2. There is a **lack of research on domestication and the development of high-yield cultivars** to improve consistency and yield.(36)
3. Farming and propagation methods are often **inefficient and outdated.**
4. **Low yields and inferior-quality products** result from inadequate processing techniques.
5. Systems for **quality control are often insufficient or absent.**
6. There is limited **research and development focused on product innovation and process improvement,** as well as difficulties in marketing herbal products.
7. **Skilled personnel and modern equipment** are in short supply.
8. There is a **lack of facilities to manufacture necessary equipment locally.**
9. Access to **up-to-date information on market trends and new technologies** is limited.

Distribution Challenges of Herbal Medicines

Herbal medicines are composed of complex mixtures of organic compounds—such as fatty acids, sterols, alkaloids, flavonoids, glycosides, saponins, tannins, lignans, terpenes, and smaller molecules like peptides and oligosaccharides—present both in the raw plant materials and their extracts.(37)

Topical Drug Delivery Systems

The primary objective of any drug delivery system is to deliver a therapeutic dose of medication to the appropriate site in the body quickly and then maintain the desired drug concentration over time. The route of administration plays a major role in determining the effectiveness of a treatment. Among all options, **the skin is one of the most accessible organs for topical application** and is frequently used for administering medications locally.(38)

Topical delivery involves applying a formulation directly onto the skin to treat localized skin disorders or to manage skin-related symptoms of systemic diseases (such as psoriasis), with the intention of confining the drug's action to the skin surface or layers. The most widely used form of topical formulations is **semi-solid preparations**, including creams, gels, and ointments. However, other formats like **foams, sprays, medicated powders, solutions, and medicated adhesive systems** are also commonly utilized.

External topical preparations are applied by spreading or spraying over the affected skin area. In contrast, internal topicals are administered to mucosal surfaces—**orally, vaginally, or in the anorectal region—to achieve local effects.**

Wound Healing and the Role of Herbal Gels

Wound healing is a **complex, dynamic process that restores tissue integrity and function** after an injury. This process progresses through four key stages: **hemostasis, inflammation, proliferation, and remodeling.** While modern medicine offers numerous synthetic and chemical-based products for wound care, concerns persist regarding their potential for **side effects, toxicity, and the development of resistance.**

Because of these issues, there is an increasing shift toward **natural treatments, especially herbal products**, valued for their therapeutic benefits, lower risk of adverse effects, and sustainability.

The main objective of this study is to **formulate and evaluate an herbal gel designed to promote wound healing**, using plant-derived ingredients that are scientifically validated for their efficacy. The formulation will include herbal extracts known for their **antimicrobial, anti-inflammatory, and antioxidant activities.**

Once prepared, the gel will undergo thorough assessment of **physicochemical properties such as pH, viscosity, spreadability, and drug release behavior.** In addition, **in vitro and in vivo studies—including antimicrobial testing and wound healing evaluations—will be conducted to verify the gel's effectiveness in supporting wound repair.**

2.1 INGREDIENTS

Ingredients and Their Functions

Formulating an herbal gel for wound healing requires combining plant-based extracts with excipients that provide suitable consistency, stability, and skin compatibility. Each ingredient has a specific role in ensuring the product is effective, safe, and acceptable to users.

Below is an in-depth explanation of *typical ingredients* used in such formulations and their functions:

1. Herbal Extracts

Herbal extracts are the primary active ingredients responsible for the wound healing effects of the gel. Depending on the selected plants, they may exert multiple pharmacological activities:

- *Aloe vera Extract:* Contains polysaccharides like acemannan that stimulate fibroblast activity, promote collagen synthesis, and accelerate re-epithelialization of wounds. Aloe also has soothing and anti-inflammatory properties.
- *Centella asiatica Extract:* Rich in asiaticoside and madecassoside, which increase collagen production, improve tensile strength of new tissue, and enhance angiogenesis (formation of new blood vessels).
- *Curcuma longa (Turmeric) Extract:* Contains curcumin, known for its powerful antioxidant, anti-inflammatory, and antimicrobial activities, which help control infection and reduce oxidative stress in the wound area.
- *Azadirachta indica (Neem) Extract:* Provides broad-spectrum antibacterial activity, helping to prevent infection and support wound cleansing.
- *Calendula officinalis Extract:* Promotes granulation tissue formation, reduces swelling, and accelerates healing.
  Function:
  Herbal extracts are responsible for the *therapeutic activity*, including antimicrobial protection, anti-inflammatory effects, antioxidant action, and stimulation of wound repair processes.

2. Gelling Agent (e.g., Carbopol or Carbomer)

- Carbopol polymers are synthetic high-molecular-weight acrylic acid cross-linked resins. They are widely used because they can form clear, stable gels at low concentrations.
  Function:
  The gelling agent provides the *semi-solid structure of the gel*, ensuring the formulation has suitable viscosity, spreadability, and the ability to remain in contact with the wound surface. It also enables uniform dispersion of the active herbal extracts.

3. Humectants (e.g., Glycerin, Propylene Glycol)

- *Glycerin:* A natural humectant that attracts and retains moisture in the skin, preventing drying and cracking around the wound.
- *Propylene Glycol:* Besides being a humectant, it enhances the *penetration of active compounds* through the skin layers, improving the bioavailability of the herbal extracts.
  Function:
  Humectants help maintain *hydration* in the wound environment, which is critical for faster healing, and ensure the gel remains smooth and easy to apply.

4. Neutralizer (Triethanolamine)

- Triethanolamine is an organic compound used to adjust the pH of formulations and neutralize the acidic gelling agent.
  Function:

It *neutralizes Carbopol*, transforming it from an acidic dispersion into a clear, stable gel. It also ensures the final pH is compatible with skin (usually around pH 5.5–6.5).(39)

5. Preservatives (Methylparaben and Propylparaben)

- Methylparaben and Propylparaben are commonly used antimicrobial preservatives in topical products.
  Function:
  Preservatives *prevent microbial contamination and growth of bacteria, yeast, and molds* during the shelf life of the gel. This is especially important for herbal formulations, as plant extracts can provide a nutrient-rich environment for microbes if not preserved properly.

6. Antioxidants (Vitamin E - Tocopherol)

- Vitamin E is a lipid-soluble antioxidant that protects the gel and the skin from oxidative damage.
  Function:
  Antioxidants *stabilize the formulation* by preventing oxidation of sensitive herbal constituents and support skin regeneration by neutralizing free radicals in the wound area.

7. Solvent (Purified or Distilled Water)

- Purified or distilled water is used as the main liquid medium for dissolving, dispersing, and mixing all ingredients.
  Function:
  Water acts as a *vehicle and solvent*, ensuring uniform dispersion of the gelling agent, humectants, preservatives, and herbal extracts. It also provides the appropriate consistency and hydration.

8. Optional Ingredients (Essential Oils)

- *Tea Tree Oil:* Offers additional antibacterial and antifungal activity.
- *Lavender Oil:* Provides soothing, mild analgesic, and antimicrobial effects.
  Function:
  Essential oils can *enhance antimicrobial properties* and contribute a pleasant fragrance, improving patient acceptability.(40)

3.1 REVIEW OF LITERATURE

Sr.No	Authors Name	Year	Key Findings
1	A, Sanjana; Ahmed, Mohammed Gulzar; Gowda, B.H. Jaswanth; Surya, Suprith	2024	The present study investigates and highlights the potency of tacrolimus (TAC) for effective Vitiligo management using the to cubosome formulation. TACloaded cubosome formulations were prepared by using the ultra sonication technique.
2	Krutika S. Bobde1 , Kanchan Upadhye , Vaibhav P. Uplanchiwar, Vinod M. Thakare , Anshu R Dudhe1 , Gayatri R. Katole1 , Namrata S. Mane1 , Prashant Bhokardankar	2023	The pharmaceutical industry's largest problem in the past year has been regulating the drug a delivery rate at specific human body place. Therefore, many scientists are contemplating the construction of novel controlled drug delivery methods to boost patient safety and effectiveness.

3	Samin Jalalmanesh Pharm D, Parvin Mansouri MD, Mehdi Rajabi Pharm D, PhD, Faezeh Monji Pharm D, PhD	2022	Vitiligo is an autoimmune and acquired disease characterized by the destruction of epidermal melanocytes leading to depigme ntation of the skin.
4	Dina B. Mahmoud , Aliaa N. ElMeshad , Maha Fadel , A beer Tawfik , Shahenda A. Ramez	2022	Vitiligo is a common autoimmu ne skin disorder in Caucasian and dark-skinned populations, that is characterized by patchy depigmentation of the skin as a result of the loss of melanocytes and melanin. Vitiligo often affects the hands and wrists;
			axillae; and perioral, periorbital, and anogenital skin of both men and women on the same level .
5	Hernandez Navarro, Sergi PhD, Segura Tejedor, Jordi PhD, Bajona Roig, Marta PhD, Luisetto, Roberto PhD, Fedrigo, Marny MD, PhD, Castellani, Chiara PhD, Angelini, Annalisa MD, PhD, Alaibac, Mauro MD, PhD, Bordignon, Matteo MD, PhD	2022	Vitiligo is an acquired chronic pigmentation disorder of skin. Even if the role of immune system seems to established, new pathogenetic hypothesis are rising in these years. It has been recently suggested by the development of an animal .
6	FEI QI, Fang Liu , Ling Gao	2021	Vitiligo is a multifactorial reversi ble skin disorder characterized by distinct white patches that result from melanocyte destructio n. Activated CXCR3$^+$ CD8$^+$ T cells promote melanocyte detach through interferon gamma (IFN γ secretion and chemokines secr eted by keratinocytes through the Janus kinase (JAK)/signal tr ansducer and activator of transc ription (STAT)-1 signaling pathway results in further recrui tment of CXCR3$^+$ CD8$^+$ T cells and the formation of a positivefeedback loop.

4.1 AIM AND OBJECTIVES

4.1 AIM:

Formulation and Evaluation of Herbal gel for Wound healing.

4.2 OBJECTIVE:

To formulate a herbal gel for the wound healing and also

1) Helps Reduce Premature Aging.
2) Might Treat Infections.
3) Reduces Inflammation.

4) Easy spread ability.
5) Good ability of absorbance in skin.
6) Treat hydration & sunburn.
7) Cooling effect.

5.1 MATERIAL AND METHODOLOGY

Preparation of Topical Herbal Gel

The herbal gel formulation was developed using Carbopol 934 as the primary gelling agent. Initially, Carbopol 934 was soaked in distilled water for 24 hours to allow complete swelling and hydration. Separately, the active herbal drug was dispersed into a small amount of glycerin with gentle heating to facilitate uniform mixing. Preservatives were also dissolved in glycerin and then combined into the Carbopol solution under continuous stirring. Finally, sodium hydroxide solution was gradually added to neutralize the acidic gel base, resulting in the formation of a clear gel.

Formulation of the Herbal Gel

This formulation incorporated Carbopol 934 along with honey and curcumin to harness their wound-healing properties. The process below outlines the preparation steps in detail:

Preparation Method

Step 1: Weighing and Organizing Ingredients

All ingredients were accurately weighed according to the quantities needed for a 100 g batch:

- *Carbopol 934* – 2 g
- *Honey* – 10 g
- *Curcumin* – 1 g
- *Potassium hydroxide* – 2 ml
- *Distilled water* – Quantity sufficient to 100 ml
- *Methyl paraben* – 0.10 g
- *Glycerin* – 5 ml

Step 2: Preparation of Aqueous Gel Base

In a clean beaker, distilled water was added, and gentle stirring was initiated. Carbopol 934 was sprinkled slowly into the water to avoid lump formation. Stirring continued until a smooth dispersion was achieved, which required sufficient time to allow complete hydration of the Carbopol.

Step 3: Preparation of Active Ingredient Mixture

Curcumin Dispersion:
As curcumin is hydrophobic, it was first dissolved in a small quantity of glycerin to improve its solubility and facilitate its incorporation into the gel matrix.

Honey Addition:
Honey was added directly into the hydrated Carbopol mixture and mixed thoroughly. Its inclusion provides moisturizing, antibacterial, and wound-healing benefits.

Step 4: Neutralization of Gel Base

Potassium hydroxide solution was slowly added under continuous stirring. This neutralization step triggers the thickening of the Carbopol, transforming it into a clear gel with appropriate consistency. The pH was carefully adjusted to fall within the skin-compatible range of 5.5–7.0.

Step 5: Addition of Preservatives

Methyl paraben, serving as an antimicrobial preservative, was incorporated into the gel base. The formulation was mixed thoroughly to ensure even dispersion and uniformity.

Step 6: Final Homogenization and Viscosity Adjustment

The final gel mixture was continuously stirred to achieve a uniform texture free of lumps and air bubbles. Viscosity was monitored to confirm the gel's spreadability and retention on the wound site.

Step 7: Packaging

Once the gel reached room temperature, it was transferred into sterilized collapsible tubes or wide-mouth jars. Containers were sealed to prevent contamination and labeled appropriately with formulation details, usage instructions, and precautions.

Evaluation of Herbal Gel

To confirm the safety, stability, and suitability of the gel for wound healing, the following evaluation parameters were conducted:

1. pH Testing

Objective:
Ensuring the pH falls within the skin's natural range (approximately 4.5–5.5) to prevent irritation.

Procedure:

- *Sample Preparation:* Weigh 1 g of gel and disperse it in 100 ml distilled water to make a 1% solution.
- *Calibration:* The pH meter was calibrated using standard buffers at pH 4.0, 7.0, and optionally 9.0.
- *Measurement:* The pH electrode was immersed into the dispersion and allowed to stabilize before recording the reading.

Evaluation:
A pH between 5.5 and 7.0 was considered acceptable for topical application.

2. Viscosity Testing

Objective:
Determining the thickness to ensure the gel is neither too fluid nor too stiff, allowing easy application and retention at the wound site.

Procedure:

- *Sample Preparation:* A homogenized sample of 1–2 g gel was placed in the viscometer container.
- *Instrument Setup:* A Brookfield Viscometer equipped with spindle number 64 was used.
- *Measurement:* The viscosity was measured at 50 RPM. Readings were repeated to ensure consistency.
- *Evaluation:* The results were expressed in centipoise (cP), with an optimal range ensuring moderate thickness.

Example Result:

- Viscosity: ~3200 cP, indicating a stable semi-solid gel.

3. Spreadability Testing

Objective:
Assessing how easily the gel spreads on the skin.

Procedure:
A known weight of the gel was placed between two glass slides, and a specific weight was applied on top. The diameter to which the gel spread was measured and used to calculate spreadability.

4. Homogeneity Testing

Objective:
Confirming the gel has a uniform appearance without lumps, grittiness, or phase separation.

Procedure:
A small amount of gel was visually inspected and gently rubbed between fingers to check for smoothness and consistency.

6.1 RESULT

The present study focused on formulating and evaluating a polyherbal gel intended for topical use in treating wounds and demonstrating antimicrobial activity. Various parameters were assessed to characterize the transdermal gel formulations. Carbopol emerged as a suitable gelling agent, providing desirable consistency and texture. Evaluation tests—including measurements of viscosity, spreadability, pH, and homogeneity—were conducted to ensure the quality of the gel. The concentration of Carbopol was optimized through a trial-and-error approach. Potassium hydroxide was used as a neutralizing agent to adjust the pH to a skin-compatible level, while also improving the gel's stability and enhancing its penetration properties. Additionally, honey was incorporated into the formulation to deliver a synergistic effect in combination with curcumin.
The study demonstrated the good antimicrobial activities and the desired physical properties of the gel formulations containing the herbal isolates. These could make them potential topical antimicrobial agents effective in the treatment of skin infections with wound healing potential and is safe to apply. The all ingredients which used in the formulation are giving maximum therapeutic effect and minimum or no adverse effect to the body. Because of the all ingredients are as natural products which are helpful and effective to the wound healing. To studied the all the perspectives the herbal gel was found to be natural products and living for the long period of time to use. From the above observations, it can be concluded that all the monographic parameters of the selected herbs were within in the Pharmacopeial limit indicates the good quality of raw materials. The microbiological studies indicated that the formulations possess wound healing activity. The wound contraction studies revealed that the wound contraction increases on increasing the concentration of herbal extract. The study also reveals the better activity of polyherbal formulation may be due to the synergistic action of the plant's constituents present in the formulation. Thus, the prepared topical gels possess a multifaceted approach in healing the wound.

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