International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

Phytopharmaceutical Development and Evaluation of a Polyherbal Gel for Wound Healing Therapy

Ms. Shejal Baghele*[1], Dr. Nisha Thakre[2] Dr. Atul Bisen[3], Dr. Rajesh Mujariya[4], Dr. Manjeet Singh[5]

[1]*Research Scholar of Institute of Pharmaceutical Science & Research, Balaghat (M.P.)*
[2]*Associate, Professor of Institute of Pharmaceutical Science & Research, Balaghat (M.P.)*
[3]*Associate, Professor of Institute of Pharmaceutical Science & Research, Balaghat (M.P.)*
[4]*Principal & Professor of Institute of Pharmaceutical Science & Research, Balaghat (M.P.)*
[5]*Executive Director of Institute of Pharmaceutical Science & Research, Balaghat (M.P.)*

Date of Submission: 17-06-2026 Date of Acceptance: 30-06-2026

ABSTRACT

Background Wound healing is a complex physiological process involving inflammation, tissue regeneration, collagen synthesis, and epithelialization. Herbal formulations have gained considerable attention as alternatives to conventional therapies due to their antimicrobial, antioxidant, anti-inflammatory, and wound healing properties. The present study was undertaken to formulate and evaluate a polyherbal gel containing *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* extracts for wound healing application.

Methods Polyherbal gel formulations (F1–F6) were prepared using varying concentrations of herbal extracts and Carbopol 934. Preliminary phytochemical screening was performed to identify major bioactive constituents. The prepared formulations were evaluated for physicochemical parameters including appearance, pH, viscosity, spreadability, homogeneity, extrudability, washability, and stability.

Results Phytochemical analysis revealed the presence of alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds in the extracts. All formulations showed good homogeneity and smooth appearance without phase separation. The pH of formulations ranged from **5.8 ± 0.03 to 6.9 ± 0.04**, indicating compatibility with skin. Viscosity values increased from **4,520 ± 45 cP (F1)** to **8,940 ± 62 cP (F6)** with increasing Carbopol concentration. Spreadability values ranged from **8.9 ± 0.12 g·cm/s (F1)** to **5.1 ± 0.08 g·cm/s (F6)**. Formulations **F3** and **F4** exhibited optimum characteristics with pH values of **6.3 ± 0.02** and **6.4 ± 0.03**, viscosities of **6,420 ± 51 cP** and **6,980 ± 48 cP**, and spreadability values of **7.5 ± 0.10 g·cm/s** and **7.1 ± 0.09 g·cm/s**, respectively. Stability studies conducted for three months showed no significant changes in color, odor, pH, or consistency.

Conclusion The developed polyherbal gel demonstrated satisfactory physicochemical properties and stability. Among all formulations, F3 and F4 showed the most desirable characteristics for topical application. The presence of multiple bioactive phytoconstituents suggests significant wound healing potential through antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative mechanisms. The formulation may serve as a safe, effective, and economical herbal alternative for wound management.

Keywords Wound Healing, Polyherbal Gel, *Ficus religiosa*, *Azadirachta indica*, *Aloe vera*, Carbopol 934, Phytochemical Screening, Topical Formulation.

I. INTRODUCTION

1.1 Definition of Wound and Wound Healing

A wound is defined as a break or disruption in the normal structure and function of the skin or underlying tissues caused by physical injury, chemical exposure, or microbial infection. Wound healing is the body's natural repair process that restores the integrity of damaged tissues. It involves a series of coordinated biological events at the cellular and molecular levels, ultimately leading to tissue regeneration and recovery of function.[1]

1.2 Types of Wounds (Acute and Chronic)

Wounds are broadly classified into **acute** and **chronic** types. Acute wounds, such as cuts, burns, and surgical incisions, heal within a normal and predictable period under proper conditions. In contrast, chronic wounds are those that fail to heal in an expected time frame, often due to underlying conditions like diabetes, poor circulation, or infection. Common examples include diabetic foot ulcers and pressure ulcers. [2]

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

1.3 Phases of Wound Healing

1.3.1 Hemostasis

This is the initial phase that occurs immediately after injury. Blood vessels constrict, and clot formation takes place to stop bleeding. The clot also acts as a protective barrier against microbial invasion.

1.3.2 Inflammation

In this phase, immune cells such as neutrophils and macrophages migrate to the wound site. They remove debris, dead cells, and pathogens. This phase is typically associated with redness, swelling, heat, and pain.

1.3.3 Proliferation

During the proliferative phase, new tissue formation begins. Fibroblasts produce collagen, angiogenesis occurs, and epithelial cells migrate to cover the wound surface, leading to gradual wound closure.

1.3.4 Remodeling

This is the final phase where the newly formed tissue undergoes maturation. Collagen fibers are reorganized, increasing the tensile strength and stability of the healed tissue. [3]

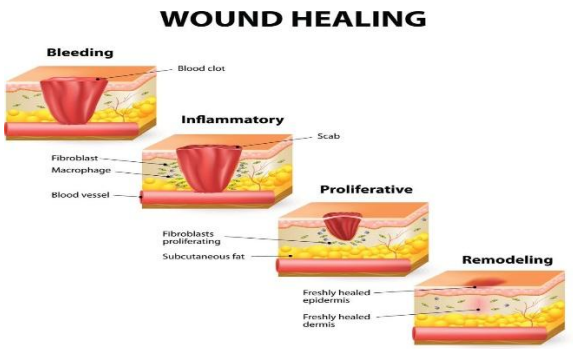

Figure 1: Phases of Wound Healing

1.4 Limitations of Synthetic Drugs

Although synthetic drugs are widely used for wound management, they have several limitations. These include potential side effects, allergic reactions, delayed healing in some cases, and the emergence of antimicrobial resistance. Such drawbacks highlight the need for alternative therapeutic approaches. [4]

1.5 Growing Importance of Herbal Formulations

Herbal formulations are gaining increasing attention due to their natural origin, safety, and cost-effectiveness. Medicinal plants contain various bioactive compounds that exhibit antimicrobial, anti-inflammatory, and antioxidant properties, which are beneficial in promoting wound healing. Polyherbal formulations, in particular, offer synergistic effects, enhancing overall therapeutic efficacy. [5]

II. Pathophysiology Of Wound Healing

2.1 Cellular and Molecular Mechanisms

Wound healing is regulated by complex interactions between different cell types, including platelets, neutrophils, macrophages, fibroblasts, and keratinocytes. These cells communicate through signaling molecules to coordinate tissue repair and regeneration. [6]

2.2 Role of Cytokines

Cytokines are signaling proteins that regulate inflammation and immune responses. They help in cell migration, proliferation, and differentiation, ensuring proper coordination of the healing process.

2.3 Role of Growth Factors (VEGF, TGF-β) [7]

Growth factors play a crucial role in wound healing. Vascular Endothelial Growth Factor (VEGF) promotes the formation of new blood vessels (angiogenesis), while Transforming Growth Factor-beta (TGF-β) stimulates collagen synthesis and tissue regeneration.

2.4 Role of Fibroblasts and Collagen [8]

Fibroblasts are essential cells responsible for producing collagen and extracellular matrix components. Collagen provides structural support and strength to the newly formed tissue, which is vital for proper wound healing.

2.5 Factors Affecting Wound Healing

2.5.1 Infection

Infection can delay the healing process by prolonging inflammation and damaging healthy tissues. [9]

2.5.2 Diabetes

Diabetes impairs blood circulation and immune function, resulting in delayed wound healing and increased risk of chronic wounds.

2.5.3 Oxidative Stress

Excess production of free radicals leads to oxidative stress, which damages cells and interferes with the normal healing process. [10]

Figure 2: Factors Affecting Wound Healing

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

III. Role Of Medicinal Plants In Wound Healing

3.1 Medicinal Plants in Wound Care

Medicinal plants have been widely used since ancient times for the treatment of wounds and skin-related disorders. In modern research, there is increasing interest in plant-based therapies due to their safety, cost-effectiveness, and broad spectrum of biological activities. Unlike synthetic drugs that often act on a single target, medicinal plants contain multiple bioactive compounds that work together to enhance the healing process. These natural agents not only support tissue repair but also reduce the risk of complications associated with wound healing. [11]

Plants are rich in phytoconstituents such as flavonoids, tannins, alkaloids, saponins, and phenolic compounds. These compounds play a crucial role in accelerating wound healing by controlling infection, reducing inflammation, and promoting the regeneration of damaged tissues. [12]

3.2 Mechanisms of Action of Medicinal Plants

Medicinal plants promote wound healing through several important mechanisms. They exhibit strong antimicrobial activity, which helps prevent infection at the wound site. Their anti-inflammatory properties reduce swelling, redness, and pain by modulating inflammatory mediators. In addition, antioxidant compounds present in plants neutralize free radicals, thereby protecting cells from oxidative damage. Many medicinal plants also enhance collagen synthesis, which is essential for tissue strength and repair. Furthermore, they promote epithelialization, leading to faster closure of the wound surface. [13]

3.3 Important Medicinal Plants Used in Wound Healing

3.3.1 Pipal (*Ficus religiosa*)

Pipal is a well-known medicinal plant with significant wound healing potential. It contains bioactive compounds such as flavonoids, tannins, and sterols, which contribute to its pharmacological effects. These constituents exhibit antioxidant and anti-inflammatory activities, helping to reduce tissue damage and support healing. Additionally, Pipal enhances collagen synthesis, which improves the structural integrity and strength of the healed tissue. [14]

Figure 3 Pipal (*Ficus religiosa*)

3.3.2 Neem (*Azadirachta indica*)

Neem is widely recognized for its potent antimicrobial and anti-inflammatory properties. It contains active constituents such as nimbidin and azadirachtin, which are effective against a variety of microorganisms. Neem helps prevent infection at the wound site and reduces inflammation, thereby promoting faster wound contraction and healing. [15]

Figure 4 Neem (*Azadirachta indica*)

3.3.3 Aloe vera (*Aloe indica*)

Aloe vera is commonly used in wound care due to its soothing and healing properties. It contains polysaccharides, vitamins, and enzymes that contribute to its therapeutic effects. Aloe vera maintains moisture at the wound site, enhances epithelialization, and stimulates fibroblast activity. These actions lead to faster tissue regeneration and improved healing outcomes. [16]

Figure 5 Aloe vera (*Aloe indica*)

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

3.4 Advantages of Using Medicinal Plants in Wound Healing

The use of medicinal plants in wound healing offers several advantages. They are natural and generally safe with minimal side effects. They are cost-effective and easily available, especially in developing countries. [17] Medicinal plants provide multiple therapeutic actions, including antimicrobial, anti-inflammatory, and antioxidant effects. They are also suitable for long-term use and have a lower risk of developing drug resistance compared to synthetic drugs. [18]

IV. Herbal Gel As A Drug Delivery System

4.1 Herbal Gel [19]

Herbal gels are semisolid dosage forms designed for topical application, incorporating plant extracts into a suitable gel base. They are widely used in wound healing due to their ability to deliver active constituents directly to the affected area. Herbal gels provide a cooling and soothing effect, enhance drug penetration, and maintain a moist environment, which is essential for effective wound healing.

4.2 Advantages of Gel [20]

- **Easy Application:** Gels are smooth, non-greasy, and can be easily applied and spread over the skin without causing discomfort.
- **Better Patient Compliance:** Due to their pleasant texture, non-sticky nature, and ease of removal, patients prefer gels over ointments or creams.
- **Controlled Release:** Gels can provide sustained and controlled release of active ingredients, ensuring prolonged therapeutic action at the wound site.

4.3 Types of Gels [21]

4.3.1 Hydrogels

Hydrogels are water-based systems that contain hydrophilic polymers. They retain moisture and provide a cooling effect, which is beneficial for wound healing. Hydrogels help in maintaining a moist environment, promoting faster tissue repair and reducing pain.

4.3.2 Organogels

Organogels are oil-based gel systems in which the liquid phase is an organic solvent. They are useful for delivering lipophilic drugs and provide better penetration through the skin. Organogels also enhance the stability of certain plant extracts.

4.4 Role of Excipients [22]

- **Carbopol:**
  Carbopol is a commonly used gelling agent that provides viscosity and structure to the gel. It helps in forming a stable and uniform gel system and ensures proper consistency.
- **Propylene Glycol:**
  Propylene glycol acts as a humectant and penetration enhancer. It helps in retaining moisture in the formulation and improves the absorption of active ingredients through the skin. [23]

2. MATERIALS AND METHODS

This section describes the procedures used for preparation and evaluation of the polyherbal wound healing gel. It includes details about plant collection, extraction, formulation, phytochemical screening, and evaluation studies. Proper methodology helps ensure accurate and reliable experimental results.

2.1 Materials

The study involved the use of medicinal plants, pharmaceutical excipients, chemicals, reagents, and laboratory instruments required for extraction and formulation of the herbal gel. All materials were selected carefully based on their compatibility and pharmaceutical importance in topical formulations.

2.1.1 Plant Materials

Fresh leaves of Ficus religiosa, Azadirachta indica, and Aloe vera were used as the active herbal ingredients. These plants were selected because of their antimicrobial, antioxidant, anti-inflammatory, and wound healing properties. Healthy and disease-free plant materials were collected from local herbal gardens and nearby natural sources.

2.1.2 Chemicals and Reagents

Various chemicals and reagents were used during extraction, phytochemical screening, formulation, and evaluation of the polyherbal gel. The major chemicals included ethanol, distilled water, Carbopol 934, hydroxypropyl methylcellulose (HPMC), propylene glycol, glycerin, and triethanolamine. Reagents such as Mayer's reagent, Dragendorff's reagent, ferric chloride solution, lead acetate solution, sodium hydroxide solution, glacial acetic acid, chloroform, and concentrated sulfuric acid were also used for phytochemical analysis. All chemicals and reagents employed in the study were of analytical grade and procured from authenticated suppliers to ensure accuracy and reliability of the experimental work.

2.1.3 Instruments Used

Several laboratory instruments and apparatus were utilized during extraction, formulation preparation, and evaluation studies. The important instruments used included Soxhlet apparatus, hot air oven, mechanical grinder, Brookfield viscometer, digital pH meter, electronic weighing balance, magnetic

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

stirrer, and water bath. Glassware such as beakers and conical flasks, along with filtration apparatus, mortar, and pestle, were also used during experimental procedures. All instruments were properly calibrated before use to maintain precision and consistency in the results.

2.2 Collection and Authentication of Plant Materials

Fresh leaves of Peepal, Neem, and Aloe vera were collected from nearby herbal gardens and natural sources. The plant materials were washed thoroughly with tap water followed by distilled water to remove dust and contaminants.

Authentication of the medicinal plants was carried out by a qualified botanist based on morphological and taxonomical characteristics. Voucher specimens were preserved for future reference. Proper authentication ensures purity, quality, and reproducibility of the herbal formulation.

2.3 Preparation of Plant Extracts

Extraction was carried out to isolate active phytoconstituents responsible for wound healing activity. Proper extraction improves the quality and therapeutic effectiveness of the herbal formulation.

2.3.1 Drying and Powdering of Plant Materials

The collected plant leaves were shade dried at room temperature to preserve heat-sensitive phytoconstituents. After complete drying, the materials were coarsely powdered using a mechanical grinder and passed through a sieve to obtain uniform particle size. The powdered samples were stored in airtight containers protected from moisture and light.

2.3.2 Extraction Methods

Plant extracts were prepared using maceration and Soxhlet extraction methods to obtain important bioactive phytoconstituents from the medicinal plants. These methods are commonly used in herbal research for effective extraction of therapeutic compounds.

2.3.2.1 Maceration Method

In the maceration method, powdered plant material was soaked in ethanol or hydroalcoholic solvent for 48–72 hours at room temperature with occasional stirring. The mixture was then filtered, and the filtrate was concentrated using a water bath to obtain a semisolid extract. The extract was stored in airtight containers under refrigerated conditions. This method is simple, economical, and suitable for heat-sensitive compounds.

2.3.2.2 Soxhlet Extraction Method

In Soxhlet extraction, dried powdered plant material was placed in a Soxhlet apparatus and extracted continuously using ethanol as solvent. The process continued until complete extraction of phytoconstituents occurred. The obtained extract was concentrated and stored for further studies. This method provides efficient extraction and higher yield of active compounds.

6.4 Phytochemical Screening

Preliminary phytochemical screening was performed to identify important secondary metabolites present in the plant extracts. These phytoconstituents contribute to antimicrobial, antioxidant, anti-inflammatory, and wound healing activities. Standard qualitative tests were carried out for alkaloids, flavonoids, tannins, saponins, and glycosides.

2.4.1 Test for Alkaloids

Alkaloids were identified using Mayer's and Dragendorff's tests. Formation of cream, yellow, or reddish-brown precipitate indicated the presence of alkaloids, which possess antimicrobial and anti-inflammatory properties.

2.4.2 Test for Flavonoids

The alkaline reagent test was performed for flavonoids. Development of yellow color that disappeared after acid addition confirmed their presence. Flavonoids help reduce oxidative stress and promote tissue repair.

2.4.3 Test for Tannins

Ferric chloride test was used to detect tannins. Appearance of blue-black or greenish-black color indicated positive results. Tannins possess astringent, antimicrobial, and wound protective properties.

2.4.4 Test for Saponins

Saponins were identified using the foam test. Formation of stable foam after shaking with water confirmed their presence. Saponins support collagen synthesis, angiogenesis, and tissue regeneration.

2.4.5 Test for Glycosides

Keller–Killiani test was carried out for glycosides. Formation of a brown ring at the junction of layers indicated positive results. Glycosides contribute to tissue repair and antioxidant activity.

Importance of Phytochemical Screening

Phytochemical screening helps identify the active constituents responsible for the therapeutic activity of medicinal plants. It also supports standardization, quality control, and scientific validation of herbal formulations. Presence of multiple phytoconstituents in the selected plants justifies their use in polyherbal wound healing gel formulation.

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

3. FORMULATION AND EVALUATION

3.1 Formulation of Polyherbal Gel

The polyherbal gel was prepared using extracts of Ficus religiosa, Azadirachta indica, and Aloe vera along with suitable pharmaceutical excipients. The formulation was designed to develop a stable and effective topical preparation for wound healing. Herbal gels are commonly preferred because they are non-greasy, soothing, easily spreadable, and provide direct delivery of active constituents to the wound site.

The selected medicinal plants possess antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative activities that help accelerate wound healing. Different excipients such as Carbopol 934, glycerin, propylene glycol, and triethanolamine were added to improve viscosity, stability, spreadability, and patient acceptability of the gel formulation.

3.1.1 Composition of Polyherbal Gel

The polyherbal gel contained herbal extracts along with gelling agents, humectants, preservatives, and pH-adjusting agents. Ficus religiosa extract was used for antioxidant and wound healing activity, Azadirachta indica extract for antimicrobial and anti-inflammatory action, and Aloe vera extract for moisturizing and tissue regeneration. Carbopol 934 acted as the gelling agent, while propylene glycol and glycerin improved hydration and penetration of active constituents.

3.1.2 Concentration of Herbal Extracts

Equal concentrations of herbal extracts were incorporated into the formulation to obtain balanced and synergistic wound healing activity. The selected concentration was intended to provide antimicrobial, antioxidant, anti-inflammatory, and collagen-promoting effects. Proper optimization of extract concentration was necessary to maintain gel stability, consistency, and therapeutic effectiveness. Excessive concentration could affect viscosity and homogeneity, whereas lower concentration might reduce pharmacological activity.

3.2 Method of Preparation

The polyherbal gel was prepared by dispersion and incorporation method. Carbopol 934 was dispersed in distilled water with continuous stirring and allowed to hydrate completely. The herbal extracts were dissolved separately in propylene glycol or water and gradually incorporated into the hydrated gel base. Glycerin was added to improve smoothness and moisturizing property.

Triethanolamine was added dropwise to neutralize the formulation and obtain suitable gel consistency and pH. The final gel was homogenized properly to obtain a smooth, uniform, and lump-free preparation. The prepared formulation was packed in airtight containers and stored at room temperature for further evaluation.

3.2.1 Preparation of Carbopol Dispersion

Carbopol 934 was slowly added to distilled water with continuous stirring to avoid lump formation. The dispersion was allowed to stand for complete hydration and swelling of the polymer. Proper hydration helped achieve suitable viscosity and smooth gel consistency.

3.2.2 Incorporation of Herbal Extracts

Accurately weighed extracts of Ficus religiosa, Azadirachta indica, and Aloe vera were dissolved separately and mixed gradually into the gel base under continuous stirring. Propylene glycol and glycerin were added to improve penetration, hydration, and spreadability of the gel.

3.2.3 Neutralization

Triethanolamine was added slowly with continuous stirring until the desired pH and semisolid consistency were achieved. Neutralization converted the Carbopol dispersion into a clear and stable gel. Proper pH adjustment was important to maintain skin compatibility and formulation stability.

3.2.4 Homogenization

The prepared gel was homogenized thoroughly to ensure uniform distribution of active ingredients and smooth texture. Homogenization improved consistency, appearance, stability, and prevented phase separation in the formulation.

3.2 Formulation of Different Batches

Different batches of the polyherbal gel were prepared by varying concentrations of herbal extracts and Carbopol 934 to optimize viscosity, spreadability, consistency, and stability. The formulations were coded as F1 to F6 for comparative evaluation.

Lower polymer concentrations produced gels with better spreadability but lower viscosity, whereas higher concentrations improved consistency and stability but slightly reduced ease of spreading. Comparative evaluation helped identify the optimized formulation with suitable physicochemical properties and patient acceptability.

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

Table 7.2: Formulation of Different Batches of Polyherbal Gel

Ingredients	F1 (% w/w)	F2 (% w/w)	F3 (% w/w)	F4 (% w/w)	F5 (% w/w)	F6 (% w/w)
Ficus religiosa Extract	1	1.5	2	2.5	3	3.5
Azadirachta indica Extract	1	1.5	2	2.5	3	3.5
Aloe vera Extract	1	1.5	2	2.5	3	3.5
Carbopol 934	0.5	0.75	1.0	1.25	1.5	2.0
Propylene Glycol	5	5	5	5	5	5
Glycerin	3	3	3	3	3	3
Methyl Paraben	0.1	0.1	0.1	0.1	0.1	0.1
Triethanolamine	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Distilled Water	q.s. to 100 g	q.s. to 100 g	q.s. to 100 g	q.s. to 100 g	q.s. to 100 g	q.s. to 100 g

3.3 Evaluation of Polyherbal Gel

Evaluation of the prepared polyherbal gel is an essential step in formulation development because it helps determine the quality, stability, safety, and therapeutic suitability of the formulation for topical application. Proper evaluation ensures that the gel possesses desirable physicochemical characteristics and is capable of delivering the active herbal constituents effectively at the wound site.

An ideal topical herbal gel should possess smooth texture, acceptable appearance, suitable viscosity, proper spreadability, homogeneity, skin-compatible pH, and good stability. These characteristics directly influence patient acceptability, therapeutic effectiveness, and ease of application. Evaluation studies also help identify any incompatibility, instability, or formulation defects that may affect the performance of the formulation during storage and use.

The prepared polyherbal gel formulations were evaluated using standard pharmaceutical procedures for various physicochemical parameters including organoleptic properties, pH, viscosity, spreadability, homogeneity, extrudability, washability, and stability. These parameters are important because they influence drug release behavior, consistency, retention at the wound site, and overall patient compliance.

3.3.1 Organoleptic Evaluation

Organoleptic evaluation involves examination of the physical appearance and sensory characteristics of the prepared gel formulation. This evaluation was carried out by visual inspection and physical observation. Parameters such as color, odor, appearance, texture, smoothness, and consistency were carefully observed.

The prepared polyherbal gel was checked for clarity, uniformity, smooth texture, and absence of lumps or coarse particles. The odor of the formulation was also evaluated to ensure patient acceptability and suitability for topical application.

Organoleptic properties are important because they directly influence patient preference and compliance. A topical gel with pleasant appearance, smooth texture, and acceptable odor is more likely to be accepted by patients. A properly formulated herbal gel should appear uniform, smooth, and free from phase separation or grittiness. Good organoleptic characteristics also indicate compatibility between herbal extracts and excipients used in the formulation.

3.3.2 pH Determination

The pH of the prepared polyherbal gel was determined using a calibrated digital pH meter. About 1 g of gel was dispersed in distilled water and allowed to stand for a few minutes before measuring the pH.

Determination of pH is an important evaluation parameter because topical formulations should possess skin-compatible pH to avoid irritation, redness, dryness, or discomfort during application. Human skin normally maintains a slightly acidic pH range of about 5.5–7. Therefore, the pH of the formulation was maintained within this range to ensure safety and compatibility with the skin.

Proper pH also helps maintain stability of the formulation and prevents degradation of active phytoconstituents. A stable pH during storage indicates good compatibility between the herbal extracts and formulation ingredients. Maintaining appropriate pH improves patient comfort, reduces chances of allergic reactions, and enhances therapeutic effectiveness of the gel formulation.

3.3.3 Viscosity Determination

Viscosity refers to the resistance of the gel to flow and indicates the thickness or consistency of the formulation. It was measured using a Brookfield viscometer under controlled conditions.

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

Viscosity is one of the most important parameters in topical gel formulations because it affects consistency, spreadability, retention at the application site, and drug release behavior. A formulation with very low viscosity may flow away from the wound site, whereas excessively high viscosity may reduce ease of spreading and patient comfort.

An ideal gel should possess balanced viscosity so that it spreads easily while remaining at the site of application for sufficient time. Proper viscosity also improves the appearance, texture, and stability of the formulation. In addition, suitable viscosity helps provide sustained release of active herbal constituents and enhances therapeutic effectiveness.

3.3.4 Spreadability Test

Spreadability is the measure of how easily the gel spreads over the skin surface. It is an important parameter because topical formulations should spread uniformly with minimal friction and effort.

In this test, a specific quantity of gel was placed between two glass slides and compressed using a definite weight. The time required for the upper slide to move over a fixed distance was measured to determine spreadability of the formulation.

Good spreadability ensures uniform distribution of the gel over the wound surface and improves contact between the formulation and skin tissues. It also enhances patient comfort and therapeutic effectiveness. Proper spreadability allows easy application without causing irritation or discomfort during use.

Spreadability is influenced by factors such as viscosity, polymer concentration, and consistency of the gel. An optimized formulation should possess balanced spreadability and viscosity for effective topical drug delivery.

3.3.5 Homogeneity

Homogeneity refers to the uniform distribution of all ingredients throughout the gel formulation. It was evaluated visually by observing smoothness, texture, and presence of any lumps or phase separation.

The prepared gel was examined for uniform appearance, smooth consistency, absence of coarse particles, and absence of grittiness. Proper homogenization ensures even distribution of active herbal constituents within the formulation.

Homogeneity is important because non-uniform formulations may lead to inconsistent drug delivery and reduced therapeutic effectiveness. A homogeneous gel improves physical stability, appearance, and texture of the formulation. Proper mixing and homogenization during preparation are essential to obtain a smooth and stable gel suitable for topical application.

3.3.6 Extrudability

Extrudability refers to the ease with which the gel can be extruded or removed from its container or collapsible tube upon application of pressure.

The extrudability of the prepared formulation was evaluated by pressing the gel-filled tube manually and observing the ease of extrusion. A properly formulated gel should come out smoothly without requiring excessive force.

Good extrudability is important because it improves convenience and patient acceptability during application. It also indicates suitable consistency and viscosity of the formulation. Poor extrudability may result from improper polymer concentration or excessively thick consistency. Therefore, evaluation of extrudability helps optimize formulation characteristics for practical use.

3.3.7 Washability

Washability determines how easily the gel can be removed from the skin surface after application. A small amount of gel was applied to the skin and washed with water to observe ease of removal.

Good washability is an important property of topical gels because it improves patient comfort and convenience during use. A washable gel does not leave excessive residue, stains, or greasy feeling on the skin.

The non-greasy and water-soluble nature of herbal gels improves their acceptability compared to ointments and creams. Easy washability also enhances patient compliance during prolonged treatment.

3.3.8 Stability Study

Stability studies were carried out to evaluate the physical stability of the prepared polyherbal gel under storage conditions. Stability testing helps determine whether the formulation maintains its quality, consistency, and therapeutic effectiveness over time.

During the stability study, the formulations were periodically observed for changes in color, odor, appearance, pH, homogeneity, consistency, and phase separation. The prepared gel formulations were stored at room temperature under suitable conditions for evaluation.

Stability studies are important because they help determine shelf life, compatibility of ingredients, and suitable storage conditions of the formulation. A stable formulation should not show significant changes in physical appearance, pH, viscosity, or consistency during storage. Good stability indicates

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

proper selection of excipients and compatibility between herbal extracts and formulation components.

4: RESULTS AND DISCUSSION

4.1 Phytochemical Screening Results

Preliminary phytochemical screening of the extracts of *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* revealed the presence of several important secondary metabolites responsible for wound healing activity. The qualitative chemical tests confirmed the presence of alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds in different extracts.

These phytoconstituents are known to possess antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative properties, which collectively contribute to wound healing. The presence of multiple bioactive compounds supports the therapeutic potential of the prepared polyherbal gel formulation.

The results of phytochemical screening are presented in Table 4.1.

Table 4.1: Phytochemical Screening Results of Herbal Extracts

Phytoconstituents	*Ficus religiosa*	*Azadirachta indica*	*Aloe vera*
Alkaloids	+	+	-
Flavonoids	+	+	+
Tannins	+	+	+
Saponins	+	-	+
Glycosides	+	+	+
Phenolic Compounds	+	+	+

Key

(+) Present

(-) Absent

Interpretation of Phytochemical Screening Results

The phytochemical analysis demonstrated that all selected medicinal plants contained significant amounts of biologically active compounds associated with wound healing activity.

- Flavonoids and phenolic compounds contribute antioxidant activity and protect tissues from oxidative stress.
- Tannins provide antimicrobial and astringent properties that help reduce infection and promote wound contraction.
- Saponins assist in tissue regeneration and collagen formation.
- Alkaloids exhibit antimicrobial and anti-inflammatory effects.
- Glycosides contribute to overall therapeutic effectiveness of the formulation.

The presence of these phytoconstituents supports the development of an effective polyherbal wound healing gel.

4.2 Formulation Characteristics

The prepared polyherbal gel formulations (F1–F6) were evaluated visually for their appearance, color, texture, consistency, and homogeneity. All formulations exhibited smooth texture and acceptable appearance without any visible lumps or phase separation.

The formulations showed characteristic herbal odor and good consistency suitable for topical application. As the concentration of Carbopol increased from F1 to F6, viscosity and thickness of the gel also increased.

Among all formulations, batch F3 and F4 exhibited better homogeneity, suitable consistency, and good spreadability compared to other batches.

Table 4.2: Formulation Characteristics of Polyherbal Gel

Formulation Code	Color	Appearance	Consistency	Homogeneity	Texture
F1	Light green	Smooth	Slightly thin	Good	Smooth
F2	Green	Smooth	Moderate	Good	Smooth
F3	Greenish-brown	Smooth	Good	Excellent	Smooth
F4	Dark green	Smooth	Good	Excellent	Smooth
F5	Dark green	Slightly thick	High	Good	Smooth
F6	Dark brownish-green	Thick	Very high	Good	Slightly thick

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

Interpretation of Formulation Characteristics

All prepared formulations showed satisfactory physical appearance and acceptable organoleptic characteristics. No phase separation or lump formation was observed in any batch.

Increase in Carbopol concentration resulted in:

- Increased viscosity
- Improved consistency
- Better retention capacity

However, excessively high polymer concentration slightly reduced spreadability in F5 and F6 formulations.

Based on visual evaluation, F3 and F4 formulations showed better overall characteristics suitable for topical wound healing application.

4.3 Physicochemical Evaluation Results

Physicochemical evaluation of the prepared polyherbal gel formulations was carried out to determine their suitability for topical application. Parameters such as pH, viscosity, and spreadability were evaluated using standard procedures.

These parameters are important because they influence:

- Stability of formulation
- Ease of application
- Drug release behavior
- Skin compatibility
- Patient compliance

4.3.1 pH Data

The pH of all formulations was found within the acceptable skin-compatible range (5.5–7), indicating suitability for topical application without causing irritation.

Table 4.3: pH of Polyherbal Gel Formulations

Formulation Code	pH
F1	5.8
F2	6.0
F3	6.2
F4	6.4
F5	6.5
F6	6.7

Interpretation of pH Results

All formulations exhibited pH values close to normal skin pH, indicating good skin compatibility and safety. No formulation showed highly acidic or alkaline nature.

The stable pH values also suggested good compatibility between herbal extracts and excipients.

4.3.2 Viscosity Data

Viscosity of the formulations was measured using a Brookfield viscometer. Increase in Carbopol concentration resulted in increased viscosity of the gel formulations.

Table 4.4: Viscosity of Polyherbal Gel Formulations

Formulation Code	Viscosity (cP)
F1	4200
F2	5100
F3	6200
F4	7100
F5	8200
F6	9300

Interpretation of Viscosity Results

The viscosity increased progressively with increase in polymer concentration. Formulations F3 and F4 exhibited suitable viscosity with good consistency and ease of application.

Lower viscosity formulations spread easily but showed lower retention, whereas higher viscosity formulations exhibited better retention but comparatively reduced spreadability.

4.3.3 Spreadability Data

Spreadability studies indicated that all formulations possessed acceptable spreading characteristics suitable for topical application.

Table 4.5: Spreadability of Polyherbal Gel Formulations

Formulation Code	Spreadability (g·cm/sec)
F1	18.5
F2	16.8
F3	15.4
F4	14.2
F5	12.9
F6	11.5

Interpretation of Spreadability Results

The spreadability of the polyherbal gel formulations gradually decreased with an increase in Carbopol 934 concentration and viscosity. Formulations F3 and F4 showed optimum spreadability with suitable consistency, making them appropriate for topical application. Good spreadability is important because it ensures easy application, uniform distribution of the gel over the wound surface, improved patient comfort, and better therapeutic effectiveness. The results indicated that moderate polymer concentration provided balanced viscosity and satisfactory spreading properties.

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

Overall Result Interpretation

Among all the prepared formulations, batches F3 and F4 exhibited the most satisfactory physicochemical properties. These formulations showed suitable pH, optimum viscosity, good homogeneity, smooth texture, acceptable consistency, and better spreadability. The gels were stable, easy to apply, and showed no phase separation or lump formation. Therefore, F3 and F4 were selected as optimized formulations for further wound healing and pharmacological studies.

4.4 Discussion

4.4.1 Interpretation of Phytochemical Results

Preliminary phytochemical screening of the extracts of *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* confirmed the presence of important bioactive constituents such as alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds. These phytoconstituents are well known for their antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative activities, which play an important role in wound healing.

Flavonoids and phenolic compounds present in the extracts may help reduce oxidative stress and protect tissues from free radical damage. Tannins may contribute to wound contraction and formation of a protective layer over the wound surface due to their astringent and antimicrobial properties. Alkaloids may help reduce microbial growth and inflammation, thereby promoting faster healing.

Saponins are known to support collagen synthesis and tissue regeneration, while glycosides contribute to cellular repair and recovery. The combined presence of these phytochemicals suggests that the selected medicinal plants possess significant wound healing potential. The synergistic action of different phytoconstituents in the polyherbal formulation may enhance overall therapeutic effectiveness and support faster tissue repair.

4.4.2 Statistical Analysis Results

Statistical analysis was carried out to evaluate the consistency and significance of the physicochemical evaluation results obtained for different gel formulations. Parameters such as pH, viscosity, and spreadability were analyzed and expressed as Mean ± Standard Deviation (SD) for triplicate observations (n = 3).

The results indicated that variations in Carbopol concentration significantly affected viscosity and spreadability of the formulations. Increased polymer concentration produced higher viscosity and comparatively lower spreadability. Formulations F3 and F4 demonstrated balanced physicochemical characteristics with suitable pH, optimum viscosity, and good spreadability.

The low standard deviation values indicated good reproducibility, consistency, and reliability of the experimental data. Overall, the statistical analysis confirmed that the prepared formulations were stable and possessed acceptable pharmaceutical properties suitable for topical wound healing application.

Table 6: Statistical Analysis of Physicochemical Evaluation Parameters (Mean ± SD, n = 3)

Formulation Code	pH (Mean ± SD)	Viscosity (cP) (Mean ± SD)	Spreadability (g·cm/sec) (Mean ± SD)
F1	5.8 ± 0.02	4200 ± 15	18.5 ± 0.20
F2	6.0 ± 0.03	5100 ± 18	16.8 ± 0.18
F3	6.2 ± 0.01	6200 ± 12	15.4 ± 0.15
F4	6.4 ± 0.02	7100 ± 16	14.2 ± 0.17
F5	6.5 ± 0.03	8200 ± 20	12.9 ± 0.14
F6	6.7 ± 0.02	9300 ± 22	11.5 ± 0.12

Interpretation of Statistical Analysis

Statistical analysis showed that all gel formulations possessed good reproducibility and consistency, as indicated by low standard deviation values. The pH of all formulations remained within the acceptable skin-compatible range, confirming their safety and stability for topical application. Viscosity increased gradually from F1 to F6 due to higher Carbopol 934 concentration, while spreadability decreased with increased viscosity, indicating an inverse relationship between these parameters. Among all batches, F3 and F4 exhibited the best balance between viscosity and spreadability and were considered the optimized formulations for wound healing application. Overall, the statistical results confirmed the successful development of a stable and effective polyherbal gel formulation.

4.4.3 Discussion on Gel Evaluation

The prepared polyherbal gel formulations were evaluated for various physicochemical parameters

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

such as appearance, pH, viscosity, spreadability, homogeneity, extrudability, washability, and stability to determine their suitability for topical wound healing application. All formulations showed smooth texture, good homogeneity, acceptable consistency, and absence of lumps or phase separation, indicating proper formulation quality and stability.

The pH of all formulations was found within the skin-compatible range, suggesting safety and reduced chances of skin irritation. Viscosity increased with higher concentration of Carbopol 934, resulting in thicker gels with improved retention at the wound site. However, excessive viscosity slightly reduced spreadability. Formulations F3 and F4 showed optimum viscosity and good spreadability, making them suitable for topical use.

Homogeneity studies confirmed uniform distribution of herbal extracts and excipients throughout the formulation. Extrudability and washability tests showed that the gels were easy to apply and remove from the skin, improving patient convenience and compliance. Stability studies indicated no significant changes in color, odor, pH, or consistency during storage, confirming good physical stability of the formulations.

Overall, F3 and F4 exhibited the best physicochemical properties and were considered optimized formulations for wound healing application. The study demonstrated that the combination of herbal extracts with suitable excipients successfully produced a stable and effective polyherbal gel.

4.4.4 Mechanism of Action of Polyherbal Gel

The polyherbal gel containing *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* promotes wound healing through multiple pharmacological mechanisms. The presence of flavonoids, tannins, alkaloids, saponins, and phenolic compounds contributes to its therapeutic activity.

The formulation exhibits anti-inflammatory activity by reducing inflammatory mediators, thereby decreasing redness, swelling, and pain at the wound site. Antioxidant constituents help neutralize free radicals and reduce oxidative stress, which protects tissues from cellular damage and supports tissue repair.

The gel also possesses antimicrobial activity, mainly due to Neem and Peepal extracts, which help inhibit microbial growth and prevent wound infection. In addition, the formulation stimulates fibroblast proliferation, collagen synthesis, epithelialization, and tissue regeneration, leading to faster wound contraction and improved healing.

4.5 Comparison with Previous Studies

The results of the present study are comparable with previously reported studies on herbal wound healing formulations. Earlier research has demonstrated that *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* possess significant antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative activities.

The prepared polyherbal gel showed suitable pH, good spreadability, optimum viscosity, and satisfactory stability, which are similar to findings reported in earlier herbal gel studies. The study also supports previous reports that polyherbal formulations produce synergistic therapeutic effects and may provide better wound healing activity compared to single-herb formulations.

V. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

The present study successfully developed and evaluated a polyherbal gel containing *Ficus religiosa*, *Azadirachta indica*, and *Aloe vera* for wound healing application. Phytochemical screening confirmed the presence of important bioactive compounds such as flavonoids, tannins, alkaloids, saponins, glycosides, and phenolic compounds, which contribute to antimicrobial, antioxidant, anti-inflammatory, and tissue regenerative activities.

The prepared gel formulations showed satisfactory physicochemical properties including suitable pH, good homogeneity, acceptable viscosity, optimum spreadability, and physical stability. Among all batches, the optimized formulations demonstrated better consistency, ease of application, and skin compatibility.

The combined action of the selected medicinal plants produced synergistic therapeutic effects that may promote wound contraction, collagen synthesis, tissue regeneration, and protection against microbial infection. Overall, the study suggests that the developed polyherbal gel is a safe, effective, and economical herbal formulation for topical wound healing therapy.

5.2 Future Scope

9.2.1 Nano-Herbal Gel Development

Future studies may focus on developing nano-herbal gel formulations to improve penetration, bioavailability, controlled drug release, and therapeutic effectiveness. Advanced systems such as nanogels and nanoemulsions may further enhance wound healing activity and formulation stability.

International Journal of Pharmaceutical research and Applications
Volume 11, Issue 3, May-June2026, pp:2317-2329 www.ijprajournal.com ISSN:2456-4494

9.2.2 Clinical Trials

Additional preclinical and clinical studies are required to confirm the safety, efficacy, and long-term therapeutic potential of the polyherbal gel in human subjects. Clinical evaluation will help establish proper dosage and comparative effectiveness with conventional therapies.

9.2.3 Commercialization Potential

The growing demand for herbal and natural products provides good opportunities for commercialization of the developed formulation. With proper standardization, quality control, regulatory approval, and large-scale production, the polyherbal gel may be developed as an affordable and patient-friendly herbal wound healing product for pharmaceutical use.

REFERENCES

[1]. Singer AJ, Clark RA. Cutaneous wound healing. *N Engl J Med*. 1999;341(10):738–746.
[2]. Martin P. Wound healing—aiming for perfect skin regeneration. *Science*. 1997;276(5309):75–81.
[3]. Gurtner GC, Werner S, Barrandon Y, Longaker MT. Wound repair and regeneration. *Nature*. 2008;453(7193):314–321.
[4]. Guo S, Dipietro LA. Factors affecting wound healing. *J Dent Res*. 2010;89(3):219–229.
[5]. Boateng JS, Matthews KH, Stevens HN. Wound healing dressings. *J Pharm Sci*. 2008;97(8):2892–2923.
[6]. Eming SA, Martin P, Tomic-Canic M. Wound repair and regeneration. Sci Transl Med.
[7]. 2014;6(265):265sr6.
[8]. Sen CK. Human wound healing. Wound Repair Regen. 2009;17(6):763–771.
[9]. Schäfer M, Werner S. Oxidative stress in wound healing. Pharmacol Res. 2008;58(2):165–171.
[10]. Percival SL, et al. Microbiology of wounds. Clin Microbiol Rev. 2012;25(2):283–308.
[11]. Udupa SL, Kulkarni DR. Anti-inflammatory plant drugs. J Ethnopharmacol. 1994;43(1):41–44.
[12]. Agyare C, et al. Medicinal plants and wound healing. Evid Based Complement Alternat Med. 2016;2016:1–12.
[13]. Thakur R, Jain N, Pathak R. Wound healing studies of plants. Evid Based Complement Alternat Med. 2011;2011:438056.
[14]. Kumar B, Vijayakumar M. Ethnopharmacology of wound healing. J Ethnopharmacol. 2007;114(2):103–113.
[15]. Biswas K, Chattopadhyay I. Biological activities of neem. Curr Sci. 2002;82(11):1336–1345.
[16]. Surjushe A, Vasani R. Aloe vera review. Indian J Dermatol. 2008;53(4):163–166.
[17]. Chithra P, Sajithlal GB. Aloe vera collagen synthesis. Indian J Exp Biol. 1998;36:896–901.
[18]. Nayak BS, Pereira LP. Medicinal plants wound healing. BMC Complement Altern Med. 2006;6:41.
[19]. Dash GK, Murthy PN. Wound healing activity. J Ethnopharmacol. 2011;134(2):446–452.
[20]. Panwar AS, Upadhyay N. Emulgel review. Asian J Pharm Life Sci. 2011;1(3):333–343.
[21]. Khullar R, Saini S. Emulgel topical delivery. Int J Pharm Biol Sci. 2011;1(3):117–128.
[22]. Garg A, Aggarwal D. Spreadability of semisolids. Pharm Technol. 2002;26(9):84–105.
[23]. Williams AC. Transdermal drug delivery. Pharmaceutical Press; 2003.
[24]. Allen LV. Dosage forms. 9th ed. Lippincott; 2012.
[25]. Aulton ME, Taylor K. Pharmaceutics. 4th ed. Elsevier; 2013.
[26]. Lachman L, Lieberman HA. Industrial pharmacy. 3rd ed. 2009.
[27]. Harborne JB. Phytochemical methods. Chapman & Hall; 1998.
[28]. Handa SS, Khanuja SPS. Extraction technologies. ICS-UNIDO; 2008.
[29]. Kokate CK. Pharmacognosy. Nirali Prakashan; 2010.