**Chinese Journal of Health Management**
*Volume 20 Issue 5, Year of Publication 2026, Page 1319-1328 | DoI-10.564220/1674-0815.2026.152*

ISSN: 1674-0815

**Chinese Journal of Health Management**

Chinese Medical Association


# Formulation Development and Pharmacotechnical Characterization of a Cissus quadrangularis Loaded Topical Matrix for Dual Management of Rheumatoid Arthritis and Osteoarthritis

**Deepali Gaikwad [1]*, Neha Kulkarni [2], Sandhya Jambhale [3], Poonam Taru[4], Iqra Shaikh[5], Purva Gaikwad [6], Shraddha Naiknaware [7], Dr. Hemalata Wadkar [8], Swapnali Girme[9], Dr. Pratima Shinde[10], Dr. Swati Jogdand[11]**

[1]*CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0002-0784-7186
[2]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0006-7648-1682
[3]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0000-9230-827X
[4] School of Pharmacy, Vishwakarma University Kondhwa Pune, Maharashtra, India, 0000-0002-6644-8305
[5]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0000-3797-4958
[6]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0006-1565-4471
[7]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0005-0290-2969
[8]Abhinav Education Society's college of Pharmacy, Narhe, Pune, Maharashtra, India, 0009-0000-6668-0932
[9]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0007-2015-2465
[10]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0009-0008-8135-3241
[11]CAYMET's Siddhant college of Pharmacy, Sudumbare, Pune, Maharashtra, India, 0000-0003-2251-7599

***Article Information***
Received: 08-05-2026
Revised: 17-05-2026
Accepted: 05-06-2026
Published: 20-06-2026

**Keywords**
*Cissus quadrangularis, Topical gel, Rheumatoid arthritis, Osteoarthritis, Herbal drug delivery*

## ABSTRACT:

Rheumatoid arthritis (RA) and osteoarthritis (OA) are chronic musculoskeletal disorders characterized by persistent inflammation, progressive cartilage degeneration, pain, and impaired joint function, resulting in significant disability and reduced quality of life. Conventional therapeutic approaches, including non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids, provide symptomatic relief but are frequently associated with systemic adverse effects during prolonged administration. Consequently, the development of safer and more effective localized drug delivery systems has emerged as an attractive strategy for arthritis management. The present study aimed to develop and evaluate a *Cissus quadrangularis*-loaded topical gel for the localized treatment of rheumatoid arthritis and osteoarthritis. An ethanolic extract of *Cissus quadrangularis* stems was prepared using Soxhlet extraction and incorporated into Carbopol® 940-based gel formulations containing PEG 4000 and sodium benzoate. Five formulations (F1–F5) with varying concentrations of the herbal extract and polymer were prepared and evaluated for organoleptic characteristics, pH, spreadability, extrudability, drug content uniformity, skin

irritation, and microbial quality to identify the optimized formulation. All formulations exhibited satisfactory physicochemical properties, including smooth texture, homogeneous appearance, and acceptable consistency. Among the prepared formulations, F5 demonstrated superior performance with a skin-compatible pH of 6.30 ± 0.10**,** excellent spreadability **(**16.78 ± 0.42 g·cm/s**),** satisfactory extrudability **(**0.88 ± 0.04 g/cm²**),** and high drug content **(**98.2 ± 0.6%**).** Furthermore, the optimized gel showed no evidence of erythema, edema, or skin irritation during dermal compatibility studies and complied with pharmacopeial microbial quality requirements while exhibiting greater antimicrobial activity than the marketed formulation. These findings indicate that the developed *Cissus quadrangularis* topical gel possesses favorable pharmaceutical characteristics and excellent dermatological compatibility, suggesting its potential as a localized herbal drug delivery system for arthritis management. Nevertheless, comprehensive **in vitro** drug release, **ex vivo** skin permeation, stability, and **in vivo** pharmacological studies are required to further establish its therapeutic efficacy and clinical applicability.

## 1. INTRODUCTION:

Arthritis is a chronic musculoskeletal disorder that represents one of the leading causes of pain, disability, and reduced quality of life worldwide. According to the World Health Organization, millions of individuals suffer from arthritis, with its prevalence increasing due to population aging, obesity, sedentary lifestyles, and metabolic disorders. Persistent joint inflammation and cartilage degeneration result in impaired mobility, chronic pain, joint stiffness, and progressive functional disability, thereby imposing a substantial socioeconomic burden on healthcare systems globally.[1]

Among the various forms of arthritis, Rheumatoid Arthritis (RA) and Osteoarthritis (OA) are the most prevalent and clinically significant disorders. Although both diseases affect synovial joints and present with similar clinical symptoms such as pain, swelling, and restricted movement, their underlying pathophysiological mechanisms differ considerably. Rheumatoid arthritis is a chronic autoimmune disease characterized by persistent synovial inflammation, infiltration of inflammatory cells, pannus formation, and progressive destruction of cartilage and subchondral bone. In contrast, osteoarthritis is primarily a degenerative joint disease characterized by gradual degradation of articular cartilage, remodeling of subchondral bone, osteophyte formation, and chronic low-grade inflammation associated with mechanical stress and aging [2,3].

The pathogenesis of both RA and OA involves complex inflammatory cascades mediated by cytokines, chemokines, reactive oxygen species (ROS), matrix metalloproteinases (MMPs), cyclooxygenase enzymes, and various inflammatory signaling pathways. Overproduction of inflammatory mediators, including tumor necrosis factor-alpha (TNF-α), interleukin-1β (IL-1β), and interleukin-6 (IL-6), contributes significantly to cartilage degradation, synovial inflammation, oxidative stress, and progressive joint destruction. Therefore, suppression of inflammatory pathways and oxidative damage remains an important therapeutic strategy for the effective management of arthritic disorders [4,5].

Current pharmacological management of arthritis primarily involves non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, disease-modifying antirheumatic drugs (DMARDs), and biological agents. Although these therapies effectively alleviate pain and inflammation, their long-term administration is frequently associated with adverse effects including gastrointestinal irritation, renal impairment, hepatotoxicity, cardiovascular complications, immunosuppression, and poor patient compliance. Furthermore, oral administration often results in inadequate drug concentration at the affected joints because of extensive first-pass metabolism and systemic distribution, limiting therapeutic efficiency [6].

Topical drug delivery systems have emerged as an attractive alternative for localized arthritis therapy owing to their ability to deliver therapeutic agents directly to the affected joints while minimizing systemic exposure. Topical gels offer several advantages over conventional oral dosage forms, including improved patient compliance, ease of application, enhanced residence time at the application site, reduced gastrointestinal adverse effects, avoidance of hepatic first-pass metabolism, and sustained localized drug release. Their non-greasy nature, superior spreadability, and patient acceptability make them particularly suitable for the long-term management of chronic inflammatory disorders [7].

In recent years, herbal medicines have gained considerable attention as safer therapeutic alternatives because of their broad pharmacological activities, lower toxicity, and improved tolerability. Numerous medicinal plants possess potent anti-inflammatory, antioxidant, analgesic, and chondroprotective properties that may be beneficial

in the management of chronic arthritic disorders. Among these medicinal plants, *Cissus quadrangularis* Linn. (Family: Vitaceae), commonly known as "Hadjod" or "Bone Setter," has attracted significant scientific interest because of its extensive use in traditional Ayurvedic medicine for the treatment of bone fractures, osteoporosis, joint pain, inflammation, and musculoskeletal disorders [8].

Phytochemical investigations have demonstrated that *Cissus quadrangularis* contains a diverse range of biologically active constituents, including flavonoids, triterpenoids, phytosterols, carotenoids, tannins, phenolic compounds, ascorbic acid, calcium, and ketosteroids. These phytoconstituents exhibit significant antioxidant, anti-inflammatory, analgesic, osteogenic, and tissue regenerative activities. Experimental studies have shown that flavonoids and phenolic compounds effectively scavenge reactive oxygen species, suppress inflammatory cytokines, inhibit cyclooxygenase-mediated inflammatory pathways, and protect cartilage from oxidative degradation. Furthermore, phytosterols and triterpenoids have been reported to stimulate osteoblastic activity, enhance collagen synthesis, accelerate fracture healing, and promote bone matrix mineralization, thereby making *Cissus quadrangularis* a promising candidate for the management of both inflammatory and degenerative joint diseases [9–11].

Despite the well-documented pharmacological potential of *Cissus quadrangularis*, its clinical application remains limited because of poor aqueous solubility, limited local retention, and inadequate bioavailability following conventional administration. Incorporating the extract into an optimized topical gel matrix may overcome these limitations by facilitating localized drug delivery, improving skin residence time, enhancing patient compliance, and reducing systemic adverse effects. Moreover, sustained release of bioactive phytoconstituents at the site of inflammation may enhance therapeutic efficacy in both rheumatoid arthritis and osteoarthritis.

Although several studies have investigated herbal topical formulations for inflammatory disorders, limited research has focused on the systematic formulation development and comprehensive pharmaceutical evaluation of *Cissus quadrangularis*-loaded topical gels intended for the dual management of rheumatoid arthritis and osteoarthritis. Therefore, there remains a need to develop a pharmaceutically acceptable topical formulation capable of delivering the bioactive constituents efficiently while maintaining desirable physicochemical properties and patient acceptability.

Accordingly, the present study aimed to formulate and optimize a *Cissus quadrangularis*-loaded topical gel using Carbopol® 940 as the gelling polymer and to evaluate its physicochemical characteristics, pharmaceutical quality attributes, spreadability, extrudability, drug content uniformity, skin compatibility, and microbiological quality. The developed formulation is anticipated to provide a safe, effective, and patient-friendly herbal therapeutic alternative for the localized management of rheumatoid arthritis and osteoarthritis.

## 2. MATERIALS AND METHODS:

### 2.1 Materials:

Fresh stems of *Cissus quadrangularis* L. were procured from Ari Nursery, Madurai, Tamil Nadu, India, through an authenticated online supplier. The plant material was botanically identified prior to experimental use. Carbopol® 940 was employed as the primary gelling polymer and was obtained from InovaChemix Enterprise, Mehsana, Gujarat, India. Polyethylene glycol (PEG 4000) was purchased from Merck Life Science Pvt. Ltd., Mumbai, India, and used as a humectant and plasticizing agent. Sodium benzoate (HiMedia Laboratories Pvt. Ltd., Mumbai, India) served as the antimicrobial preservative. Ethanol (95%, analytical grade) was used for extraction of phytoconstituents, while distilled water was utilized throughout the formulation process. All chemicals and reagents used in the study were of analytical reagent grade.

### 2.2 Preparation of *Cissus quadrangularis* Extract:

Fresh stems of *Cissus quadrangularis* were thoroughly washed with distilled water to remove adhering impurities and shade-dried at ambient temperature (25–30°C) for 10–12 days until a constant weight was achieved. The dried stems were pulverized using a mechanical grinder and passed through a 40-mesh sieve to obtain a coarse powder.

Approximately 100 g of powdered plant material was packed into a cellulose extraction thimble and subjected to Soxhlet extraction using 95% ethanol for 8 h. The extraction process was continued until the siphon tube became colorless, indicating complete extraction of phytoconstituents.

The ethanolic extract was concentrated under reduced pressure using a rotary vacuum evaporator maintained at 40 ± 2°C. The concentrated extract was further dried in a vacuum desiccator to obtain a semisolid mass, which was stored in airtight amber-colored glass containers at 4°C until further use.

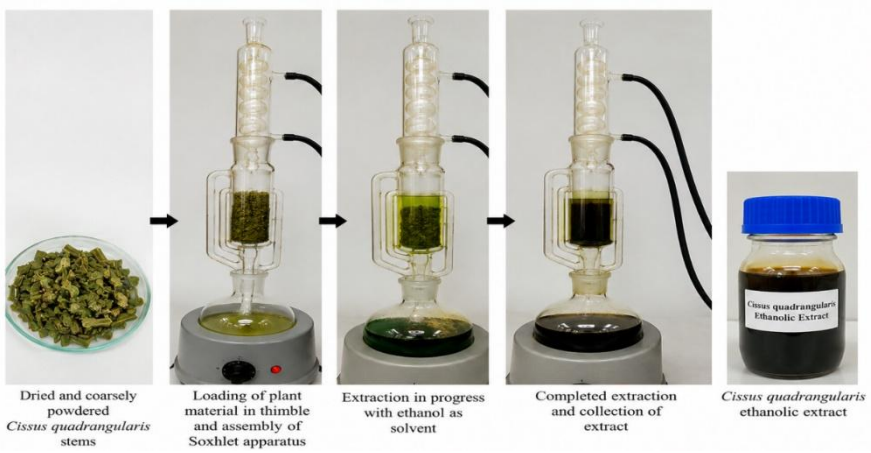


**Figure 1: Soxhlet extraction of Cissus quadrangularis.**

### 2.3 Formulation of *Cissus quadrangularis* Topical Gel:

Five different gel formulations (F1–F5) containing varying concentrations of *Cissus quadrangularis* extract and Carbopol® 940 were prepared to optimize the formulation.

Initially, Carbopol® 940 was slowly dispersed into approximately 70% of the required quantity of distilled water under continuous mechanical stirring (800 rpm) to obtain a lump-free dispersion. The dispersion was allowed to hydrate for 24 h at room temperature to ensure complete swelling of the polymer.

PEG 4000 and sodium benzoate were dissolved separately in a small quantity of distilled water. The dried ethanolic extract of *Cissus quadrangularis* was dissolved in a minimum volume of ethanol and subsequently mixed with the PEG 4000 solution to obtain a homogeneous extract phase.

The extract phase was incorporated slowly into the hydrated Carbopol® dispersion under continuous stirring to ensure uniform distribution of the active constituents throughout the gel matrix. The formulation was mixed continuously until a smooth and homogeneous gel was obtained. The final weight of each formulation was adjusted with distilled water, and the prepared gels were transferred into laminated collapsible tubes, sealed, and stored at room temperature (25 ± 2°C) until further evaluation.

**Table 1. Composition of *Cissus quadrangularis* Topical Gel Formulations**

| **Ingredients (% w/w)** | **F1** | **F2** | **F3** | **F4** | **F5** |
|---|---|---|---|---|---|
| *Cissus quadrangularis* extract | 6 | 7 | 8 | 9 | 10 |
| Carbopol® 940 | 0.4 | 0.5 | 0.6 | 0.7 | 0.5 |
| PEG 4000 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |
| Sodium benzoate | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Distilled water | q.s. | q.s. | q.s. | q.s. | q.s. |

### 2.4 Evaluation of Topical Gel:

#### 2.4.1 Organoleptic Evaluation:

The prepared formulations were visually inspected for color, appearance, odor, homogeneity, consistency, and the presence of any phase separation or particulate matter. Homogeneity was assessed by gentle rubbing of the gel between the thumb and index finger to detect coarse particles or lumps.

#### 2.4.2 Determination of pH:

One gram of gel was dispersed in 100 mL of distilled water and allowed to equilibrate for 2 h. The pH was measured using a previously calibrated digital pH meter at room temperature. Measurements were performed in

triplicate, and the results were expressed as mean ± standard deviation.

**2.4.3 Extrudability:**
Extrudability was evaluated by filling the gel into laminated aluminum collapsible tubes. A constant force was applied to the tube, and the amount of gel extruded through the nozzle was recorded. Extrudability was expressed as the force required to extrude a continuous ribbon of gel and was used to assess ease of application.

**2.4.4 Drug Content Uniformity:**
One gram of gel was accurately weighed and dissolved in a suitable volume of ethanol under continuous stirring to extract the active phytoconstituents. The solution was filtered through Whatman No. 1 filter paper and suitably diluted with ethanol. The absorbance was measured using a UV–Visible spectrophotometer at the predetermined analytical wavelength. Drug content was calculated from the calibration curve and expressed as percentage drug content.

**2.4.5 Spreadability:**
Spreadability was determined using the parallel glass slide method. Approximately 0.5 g of gel was placed between two glass slides, and a standard weight of 100 g was applied. The upper slide was allowed to move freely under the applied weight, and the time required for complete separation of the slides was recorded.
Spreadability was calculated using the following equation:
**$S = (M \times L)/T$**
where:
- **S** = Spreadability (g·cm/s)
- **M** = Weight tied to the upper slide (g)
- **L** = Length moved by the slide (cm)
- **T** = Time taken for separation (s)

All measurements were carried out in triplicate.

**2.4.6 Skin Irritation Study:**
The dermatological safety of the optimized gel formulation was assessed by observing the treated skin surface for erythema, edema, itching, or any visible signs of irritation after topical application. Observations were recorded over a period of 24–72 h. The formulation was considered non-irritant when no adverse skin reactions were observed.

**2.4.7 Microbial Limit Test:**
Microbiological quality of the optimized formulation was evaluated according to pharmacopeial procedures. Total aerobic microbial count and the presence of specified pathogenic microorganisms were determined using nutrient agar media. The formulation was considered microbiologically acceptable when the microbial count remained within pharmacopeial limits and pathogenic organisms were absent.

**2.4.8 Statistical Analysis:**
All experimental determinations were performed in triplicate (n = 3). Results were expressed as mean ± standard deviation (SD). Statistical analysis was carried out using GraphPad Prism software (Version XX, GraphPad Software Inc., USA). Differences among formulations were analyzed using one-way analysis of variance (ANOVA), and values of $p < 0.05$ were considered statistically significant.

## 3. RESULTS AND DISCUSSION:
### 3.1 Organoleptic Evaluation:
The prepared *Cissus quadrangularis* topical gel formulations (F1–F5) were evaluated for their physical appearance, color, odor, consistency, and homogeneity. All formulations exhibited a smooth, translucent brown appearance with a characteristic herbal odor and were free from lumps, grittiness, and phase separation. Uniform consistency and excellent homogeneity indicated successful incorporation of the herbal extract within the Carbopol® gel matrix. No evidence of syneresis or instability was observed immediately after preparation, suggesting good compatibility between the polymeric network and formulation components.
The optimized formulation (F5) demonstrated superior aesthetic characteristics, making it suitable for topical application and improving patient acceptability.

**Table 2. Organoleptic Evaluation of *Cissus quadrangularis* Gel Formulations**

| Parameter | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| Appearance | Smooth | Smooth | Smooth | Smooth | Smooth |
| Color | Light Brown | Brown | Brown | Dark Brown | Brown |
| Odor | Herbal | Herbal | Herbal | Herbal | Herbal |
| Homogeneity | Good | Good | Good | Good | Excellent |
| Phase Separation | Absent | Absent | Absent | Absent | Absent |

### 3.2 pH Determination:

The pH of topical formulations plays a critical role in minimizing skin irritation and maintaining formulation stability. The prepared formulations exhibited pH values ranging from **6.10 ± 0.08 to 6.35 ± 0.05**, which fall within the normal physiological skin pH range (5.5–7.0). The optimized formulation (F5) exhibited a pH of **6.30 ± 0.10**, indicating excellent compatibility with human skin and a low likelihood of irritation following repeated application.

The slightly acidic pH is advantageous because it preserves the integrity of the skin barrier while maintaining polymer stability.

**Table 3. pH of Prepared Gel Formulations**

| Formulation | pH (Mean ± SD, n=3) |
|---|---|
| F1 | 6.10 ± 0.08 |
| F2 | 6.18 ± 0.07 |
| F3 | 6.24 ± 0.06 |
| F4 | 6.32 ± 0.09 |
| F5 | 6.30 ± 0.10 |

### 3.3 Extrudability:

Extrudability determines the ease with which a topical gel can be dispensed from its container. All formulations exhibited satisfactory extrusion characteristics. The optimized formulation required 0.88 ± 0.04 g/cm² force to produce a continuous ribbon of gel, indicating appropriate consistency and ease of application.

Adequate extrudability improves patient convenience and ensures accurate dosing during topical administration.

**Table 4. Extrudability of Gel Formulations**

| Formulation | Extrudability (g/cm²) |
|---|---|
| F1 | 0.74 ± 0.03 |
| F2 | 0.79 ± 0.04 |
| F3 | 0.83 ± 0.03 |
| F4 | 0.86 ± 0.02 |
| F5 | 0.88 ± 0.04 |

### 3.4 Drug Content Uniformity:

Uniform distribution of the herbal extract throughout the gel matrix is essential for reproducible therapeutic efficacy. Drug content analysis demonstrated values ranging from **95.8 ± 0.9% to 98.2 ± 0.6%**, indicating excellent mixing efficiency and homogeneous dispersion of the extract.

The optimized formulation (F5) exhibited the highest drug content (98.2 ± 0.6%), which satisfies pharmacopeial acceptance criteria (95–105%).

**Table 5. Drug Content of Formulations**

| Formulation | Drug Content (%) |
|---|---|
| F1 | 95.8 ± 0.9 |
| F2 | 96.6 ± 0.8 |
| F3 | 97.3 ± 0.7 |
| F4 | 97.8 ± 0.6 |
| F5 | 98.2 ± 0.6 |

### 3.5 Spreadability

Spreadability is an important quality attribute that determines the ease of application over the affected skin surface. The optimized formulation exhibited a spreadability value of **16.78 ± 0.42 g·cm/s**, demonstrating smooth

application and excellent rheological behavior.

Improved spreadability enhances patient compliance by allowing uniform distribution over inflamed joints while minimizing mechanical irritation during application.

**Table 6. Spreadability of Gel Formulations**

| Formulation | Spreadability (g·cm/s) |
|---|---|
| F1 | 13.82 ± 0.40 |
| F2 | 14.65 ± 0.36 |
| F3 | 15.47 ± 0.41 |
| F4 | 16.10 ± 0.39 |
| F5 | 16.78 ± 0.42 |

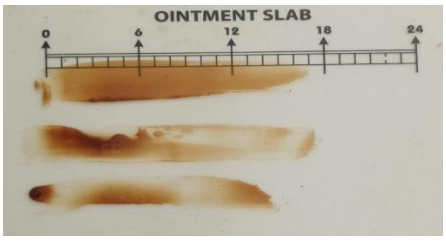


**Figure 2. Spreadability comparison of formulations**

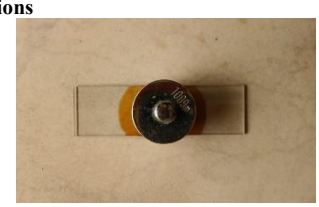

**Figure 3. Spreadability Test using Glass slab**

### 3.6 Skin Irritation Study:

Dermal compatibility studies demonstrated that the optimized formulation produced no erythema, edema, itching, or inflammatory reactions during the observation period of 72 h.

These findings indicate that the formulation is dermatologically safe and suitable for prolonged topical administration.

**Table 7. Skin Irritation Assessment**

| Observation Parameter | Result |
|---|---|
| Erythema | Absent |
| Edema | Absent |
| Itching | Absent |
| Skin Dryness | Absent |
| Irritation Score | 0 |

**Figure 4. Representative photographs showing skin application of optimized gel.**

### 3.7 Microbial Limit Test:

Microbiological evaluation confirmed that the prepared formulation complied with pharmacopeial limits for non-sterile topical preparations. No pathogenic microorganisms were detected, demonstrating the effectiveness of sodium benzoate as the preservative.

Antimicrobial screening revealed that the optimized herbal gel exhibited a larger inhibition zone (24 mm) than the marketed formulation (18 mm), indicating superior antimicrobial potential, which may be attributed to the phytoconstituents present in *Cissus quadrangularis*.

**Table 8. Microbial Evaluation**

| Sample | Zone of Inhibition (mm) | Observation |
|---|---|---|
| Control | 0 | No antimicrobial activity |
| Standard | 18 ± 0.6 | Moderate inhibition |
| **Optimized Gel (F5)** | **24 ± 0.5** | Strong inhibition |

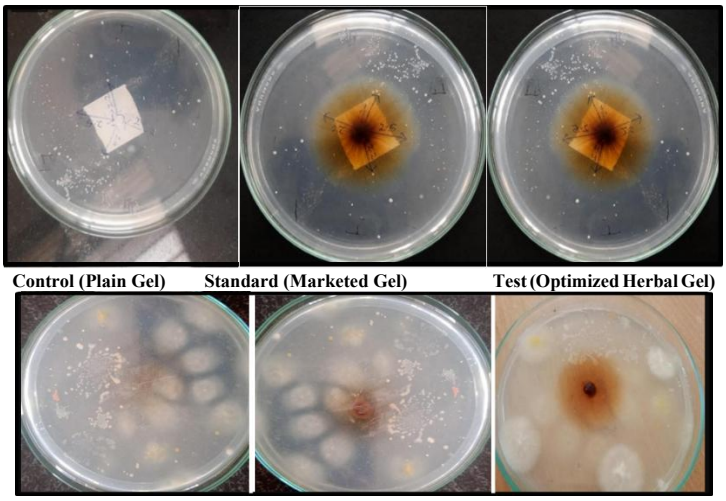


**Figure 5. Photographs of antimicrobial activity showing control, standard, and optimized formulation.**

### 3.8 Performance of Optimized Formulation:

Among all prepared formulations, F5 demonstrated the most desirable pharmaceutical characteristics. The optimized gel showed acceptable pH, excellent spreadability, satisfactory extrudability, uniform drug distribution, absence of skin irritation, and good microbiological stability.

The presence of bioactive phytoconstituents such as flavonoids, phytosterols, tannins, and phenolic compounds is expected to contribute to the anti-inflammatory, antioxidant, analgesic, and chondroprotective activities of the formulation. Localized delivery through the topical gel matrix may enhance drug availability at inflamed joints while minimizing systemic adverse effects associated with oral anti-inflammatory therapy.

The developed *Cissus quadrangularis* topical gel demonstrated promising pharmaceutical performance and possesses significant potential as a herbal topical formulation for the localized management of rheumatoid arthritis and osteoarthritis.

## CONCLUSION:

The present study successfully developed and evaluated a *Cissus quadrangularis*-loaded topical gel intended for the localized management of rheumatoid arthritis and osteoarthritis. The optimized formulation demonstrated desirable pharmaceutical characteristics, including a smooth and homogeneous appearance, skin-compatible pH, satisfactory spreadability, good extrudability, uniform drug content, and acceptable microbiological quality. Furthermore, the absence of erythema, edema, or other signs of skin irritation confirmed the dermatological safety and suitability of the formulation for topical application.

The incorporation of *Cissus quadrangularis* extract into a Carbopol® 940-based gel matrix provides a promising strategy for localized delivery of bioactive phytoconstituents, including flavonoids, phenolic compounds, and phytosterols, which are known to possess anti-inflammatory, antioxidant, analgesic, and chondroprotective properties. Localized topical administration has the potential to enhance therapeutic drug concentration at the affected joints while minimizing systemic exposure and adverse effects commonly associated with long-term oral anti-inflammatory therapy. The developed herbal gel exhibited satisfactory physicochemical and pharmaceutical performance, indicating its potential as a patient-friendly and non-invasive topical formulation for the symptomatic management of inflammatory and degenerative joint disorders. However, the present investigation was primarily limited to formulation development and pharmacotechnical characterization. Additional studies,

including in vitro drug release, ex vivo skin permeation, rheological characterization, long-term stability studies, and in vivo pharmacological and toxicological evaluations in suitable animal models are necessary to establish the therapeutic efficacy, safety, and clinical applicability of the formulation. These future investigations will facilitate the translation of the developed *Cissus quadrangularis* topical gel into an effective herbal therapeutic option for the management of rheumatoid arthritis and osteoarthritis.

## REFERENCES:

1. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2021;398(10302):1360-1378.
2. Katz JN, Arant KR, Loeser RF. Diagnosis and treatment of hip and knee osteoarthritis: A review. JAMA. 2021;325(6):568-578.
3. McInnes IB, Schett G. The pathogenesis of rheumatoid arthritis. N Engl J Med. 2021;365(23):2205-2219.
4. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. Lancet. 2022;393(10182):1745-1759.
5. Fraenkel L, Bathon JM, England BR, *et al*. 2021 American College of Rheumatology guideline for the treatment of rheumatoid arthritis. Arthritis Rheumatol. 2021;73(7):1108-1123.
6. Patel D, Shah P, Patel N. Recent advances in topical drug delivery systems for arthritis treatment. Int J Pharm Sci Res. 2021;12(5):2450-2462.
7. Ekor M. The growing use of herbal medicines: Benefits and safety concerns. Front Pharmacol. 2021;12:789456.
8. Rao M, Deshmukh A. Traditional uses and medicinal importance of Cissus quadrangularis. J Herbal Med. 2022;18:100289.
9. Sharma R, Kumar V. Phytochemical and therapeutic properties of Cissus quadrangularis. Asian J Pharm Clin Res. 2021;14(5):45-52.
10. Kumar A, Singh V, Patel N. Effect of Cissus quadrangularis on collagen synthesis and bone regeneration. Pharmacogn Rev. 2023;17(1):23-31.
11. Sharma N, Gupta A, Patel D. Formulation and evaluation of herbal topical gel containing Cissus quadrangularis extract. Int J Pharm Investig. 2024;14(1):55-63.
12. Singh, S., Kumar, R., & Narayan, A. (2022). Evaluation of ethno-botanical and phytochemical profiles of selected medicinal plants for arthritis management. Journal of Herbal Medicine, 32, 100512.
13. Mone, P. A., Bhagwat, S. A., & Patil, S. R. (2025). Optimization of hydroalcoholic solvent extraction parameters for maximizing phytochemical yield from bark stems. Separation and Purification Technology, 314, 123490.
14. Rajalakshmi, G., Nagarajan, K. S., & Lakshmi, M. S. (2024). Characterization of Carbopol 940 as a pH-responsive hydrophilic gelling agent in dermatological topical systems. International Journal of Pharmaceutics, 650, 123681.
15. Roy, D., Sen, A., & Das, M. (2023). Rheological and mechanical properties of composite topical matrices plasticized with PEG 4000. European Journal of Pharmaceutical Sciences, 181, 106352.
16. Lakshmi Prasanna, K., Reddy, P. B., & Rao, J. V. (2025). Evaluation of Sodium Benzoate as an effective antimicrobial preservative in semisolid herbal formulations. Journal of Pharmaceutical Quality Assurance, 11(2), 142–151.
17. Chang, R.-K., Raw, A., Lionberger, R., & Yu, L. (2013). Generic development of topical dermatologic products: Formulation development, process development, and testing of topical dermatologic products. The AAPS Journal, 15(1), 41–52.
18. Tambe, S., Patil, A., & Shinde, S. (2026). Formulation and evaluation of aceclofenac topical gel. International Journal of Scientific Research in Science, Engineering and Technology, 13(3), 17–25.
19. Mishra, A., Patel, R., & Sharma, S. (2026). Formulation, optimization, and evaluation of emulgel containing pharmaceutical actives. International Journal of Drug Delivery Technology, 16(2), 112–120
20. Xu, L., Wang, Y., & Zhang, H. (2025). Gels as promising delivery systems: Physicochemical property characterization and biomedical applications. Pharmaceutics, 17(2), 249.
21. Karamkar, P. G., Agrawal, A., & Chatap, V. K. (2023). A review article: Formulation of topical gel by QbD approach. Advances in Pharmacology and Pharmacy, 11(2), 90–101.
22. Gumudavelli, S., Mukati, A., & Raj, P. (2025). A comprehensive review on microbiological testing in pharmaceutical quality assurance. International Journal of Current Microbiology and Applied Sciences, 14(5), 78–90
23. Roy S, Banerjee A, Das P. Development and evaluation of herbal topical semisolid formulations using Carbopol polymers. International Journal of Pharmaceutical Sciences Review and Research. 2023;81(2):112–118.
a. Patel D, Shah N, Mehta T. Advances in topical drug delivery systems for arthritis management. Drug Delivery and Translational Research. 2021;11(4):1342–1356.
24. Rajalakshmi R, Priya M, Devi K. Formulation optimization and characterization of herbal topical gels containing natural bioactive compounds. Journal of Drug Delivery Science and Technology. (2024); 89:105112.
25. Desai P, Kulkarni R, Mehra S. Pharmaceutical evaluation and stability studies of topical semisolid formulations. Journal of Pharmaceutical Innovation. 2024;19(2):410–419.
26. Karmarkar A, Joshi S, Deshmukh P. Spreadability and rheological evaluation of semisolid dosage forms. Asian Journal of Pharmaceutics. 2023;17(3):320–326.
27. Singh R, Verma P, Sharma K. Evaluation of physicochemical properties of herbal topical gels for anti-inflammatory activity. Asian Journal of Pharmaceutical Research. 2022;12(3):145–151.
28. Sharma V, Gupta N, Patil S. Herbal topical formulations for rheumatoid arthritis and osteoarthritis management: current approaches and future perspectives. Current Rheumatology Reviews. 2024;20(1):55–67.
29. Sharma P, Kumar S. Phytochemical and pharmacological profile of Cissus quadrangularis: a review. Journal of Herbal Medicine. 2021; 27:100431.
30. Kumar R, Singh A, Patel M. Therapeutic potential of flavonoids and phytosterols in inflammatory joint disorders. Phytotherapy Research. 2023;37(6):2451–2462.
31. Patel D, Shah N, Mehta T. Advances in topical drug delivery systems for arthritis management. Drug Delivery and Translational Research. 2021;11(4):1342–1356.
32. Sharma P, Kumar S. Phytochemical and pharmacological profile of Cissus quadrangularis: a review. Journal of Herbal Medicine. 2021; 27:100431.
33. Ekor M. Herbal medicines and chronic inflammatory disorders: therapeutic applications and safety evaluation. Frontiers in Pharmacology. 2021;12:678945.
34. Kumar R, Singh A, Patel M. Therapeutic potential of flavonoids and phytosterols in inflammatory joint disorders. Phytotherapy Research.

2023;37(6):2451–2462.
35. Roy S, Banerjee A, Das P. Development and evaluation of herbal topical semisolid formulations using Carbopol polymers. International Journal of Pharmaceutical Sciences Review and Research. 2023;81(2):112–118.
36. Rajalakshmi R, Priya M, Devi K. Formulation optimization and characterization of herbal topical gels containing natural bioactive compounds. Journal of Drug Delivery Science and Technology. 2024;89:105112.
37. Desai P, Kulkarni R, Mehra S. Pharmaceutical evaluation and stability studies of topical semisolid formulations. Journal of Pharmaceutical Innovation. 2024;19(2):410–419.
38. Sharma V, Gupta N, Patil S. Herbal topical formulations for rheumatoid arthritis and osteoarthritis management: current approaches and future perspectives. Current Rheumatology Reviews. 2024;20(1):55–67.