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# Formulation And Evaluation of Polyherbal Gel for Analgesic Anti-Inflammatory Activity

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## ABSTRACT:
Pain and inflammation are among the most common clinical conditions requiring effective and safe therapeutic interventions. Herbal topical formulations have gained increasing attention due to their natural origin, reduced adverse effects, and enhanced patient acceptability. The present study aimed to formulate and evaluate a polyherbal gel containing linseed (Linum usitatissimum) oil and sunflower (Helianthus annuus) oil along with peppermint oil, eucalyptus oil, clove oil, rosemary oil, camphor, and turpentine oil for topical analgesic and anti-inflammatory application. Linseed and sunflower oils were extracted using the Soxhlet extraction method with *n*-hexane and standardized by determining acid value and saponification value prior to formulation. Six gel formulations (F1–F6) were prepared using Carbopol 934 as the gelling agent and triethanolamine as the neutralizing agent. The prepared formulations were evaluated for physicochemical characteristics, including appearance, homogeneity, pH, viscosity, spreadability, washability, patch test, and stability. All formulations exhibited satisfactory physicochemical properties with good homogeneity, pleasant odor, acceptable viscosity, and excellent spreadability. The gels were non-irritant during patch testing and remained physically stable during the storage period. Among the developed formulations, **F5** demonstrated superior overall performance and stability compared with the other batches. The findings indicate that the developed polyherbal gel possesses desirable physicochemical characteristics and has potential as a topical herbal formulation for the management of pain and inflammation. However, further pharmacological and clinical studies are required to establish its analgesic and anti-inflammatory efficacy.

## INTRODUCTION:
Pain and inflammation are complex physiological responses triggered by tissue injury, infection, or immune-mediated disorders. Although inflammation serves as a protective mechanism that facilitates tissue repair and eliminates harmful stimuli, persistent or uncontrolled inflammation contributes to chronic diseases such as arthritis, musculoskeletal disorders, neuropathic pain, and inflammatory skin conditions. Conventional

pharmacological therapies, including non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids, remain the mainstay of treatment; however, their prolonged use is frequently associated with adverse effects such as gastrointestinal ulceration, cardiovascular complications, renal toxicity, and hepatic dysfunction. Consequently, there is growing interest in developing safer and more effective alternatives derived from natural products.[1–3]

Topical drug delivery systems have emerged as an attractive therapeutic approach for the localized treatment of pain and inflammation because they deliver the active constituents directly to the affected site while minimizing systemic exposure and first-pass metabolism. Topical formulations improve patient compliance, reduce gastrointestinal adverse effects, and provide sustained local drug concentrations. Among various topical dosage forms, gels are widely preferred owing to their non-greasy nature, ease of application, excellent spreadability, rapid drug release, cooling sensation, and high patient acceptability. Carbopol-based gels have been extensively employed due to their excellent rheological characteristics, stability, and compatibility with herbal extracts and essential oils.[4–6]

Medicinal plants and essential oils possess a wide range of bioactive phytochemicals, including flavonoids, phenolic acids, terpenoids, alkaloids, lignans, and polyunsaturated fatty acids, which exhibit anti-inflammatory, analgesic, antioxidant, antimicrobial, and wound-healing activities. Herbal formulations containing multiple plant-derived ingredients may provide synergistic therapeutic effects by modulating several inflammatory pathways simultaneously while reducing the likelihood of adverse reactions associated with synthetic drugs. Therefore, polyherbal topical formulations have gained considerable attention for the management of pain and inflammatory disorders.[7–9]

**Linum usitatissimum** (linseed or flaxseed) is an important medicinal plant rich in α-linolenic acid (ALA), lignans, dietary fiber, and phenolic compounds. Flaxseed oil has demonstrated antioxidant, anti-inflammatory, cardioprotective, and analgesic properties in several experimental studies. The high concentration of omega-3 fatty acids suppresses the production of pro-inflammatory mediators, including prostaglandins, leukotrienes, tumor necrosis factor-α (TNF-α), and interleukins, thereby reducing inflammatory responses.[10–12]

Similarly, **Helianthus annuus** (sunflower) seed oil is a rich source of linoleic acid, oleic acid, tocopherols, phytosterols, and other antioxidant constituents. Sunflower oil exhibits emollient, antioxidant, anti-inflammatory, and skin barrier-restoring properties, making it an attractive candidate for topical pharmaceutical formulations. The presence of vitamin E and unsaturated fatty acids contributes to protection against oxidative stress while promoting skin hydration and tissue repair.[13–15]

In addition to these vegetable oils, essential oils such as peppermint, eucalyptus, clove, rosemary, turpentine oil, and camphor possess well-documented analgesic and anti-inflammatory activities. Menthol present in peppermint oil activates transient receptor potential melastatin-8 (TRPM8) channels, producing a cooling sensation and analgesic effect. Eugenol from clove oil inhibits cyclooxygenase-mediated prostaglandin synthesis, whereas eucalyptol (1,8-cineole) and camphor reduce inflammatory mediator release and improve local blood circulation. Rosemary oil contains carnosic acid and rosmarinic acid, which exhibit antioxidant and anti-inflammatory effects. The combination of these herbal oils may therefore provide complementary mechanisms for pain relief and inflammation control.[16–20]

Despite the therapeutic potential of these medicinal oils, limited studies have investigated their incorporation into a single polyherbal topical gel for analgesic and anti-inflammatory applications. Therefore, the present study was undertaken to formulate a Carbopol 934-based polyherbal gel containing linseed oil, sunflower oil, peppermint oil, eucalyptus oil, clove oil, rosemary oil, turpentine oil, and camphor. The prepared formulations were evaluated for physicochemical properties including appearance, pH, viscosity, spreadability, washability, patch test, and stability to identify the optimized formulation suitable for topical application.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Linseed (*Linum usitatissimum*) seeds and sunflower (*Helianthus annuus*) seeds were procured from a local seed market in Pune, Maharashtra, India. Peppermint oil, eucalyptus oil, clove oil, rosemary oil, camphor, and turpentine oil were obtained from an authenticated herbal supplier. Carbopol 934 was used as the gelling agent, Tween 80 as the emulsifying agent, glycerin as a humectant, methyl paraben as the preservative,

ethylenediaminetetraacetic acid (EDTA) as the chelating agent, triethanolamine as the neutralizing agent, and n-hexane (analytical grade) as the extraction solvent. All chemicals and reagents used in the study were of analytical reagent (AR) grade.[1–3]

**2.2 Extraction of Linseed and Sunflower Oils**

Fresh linseed and sunflower seeds were washed thoroughly with distilled water to remove adhering impurities and subsequently shade-dried for two weeks. The dried seeds were pulverized using a laboratory grinder and sieved through a 40-mesh sieve to obtain a uniform powder.

Approximately 30 g of powdered seed material was packed into a cellulose extraction thimble and subjected to Soxhlet extraction using 250 mL of n-hexane for 6 h at 30–40°C. The extract was filtered and the solvent was removed using a rotary evaporator under reduced pressure. The extracted oils were stored in amber-colored airtight glass containers at 4°C until further use.[4,5]


**Figure 1. Flow diagram for extraction of seed oils**

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**Figure 2. Soxhlet extraction of Linseed oil**

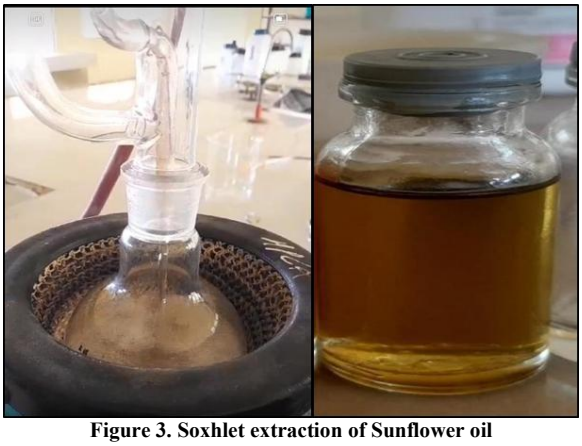

**Figure 3. Soxhlet extraction of Sunflower oil**

### 2.3 Physicochemical Characterization of Extracted Oils

The extracted linseed and sunflower oils were standardized by determining acid value and saponification value according to standard pharmacopeial procedures.

#### 2.3.1 Determination of Acid Value

One gram of oil sample was transferred into a conical flask containing previously neutralized ethanol. Phenolphthalein indicator was added, and the solution was titrated against 0.1 N ethanolic potassium hydroxide until a persistent pale pink endpoint appeared.

The acid value was calculated using the following equation:

$$\text{Acid Value} = \frac{V \times N \times 56.1}{W}$$

where

- **V** = volume of KOH (mL)
- **N** = normality of KOH
- **W** = weight of oil (g)

#### 2.3.2 Determination of Saponification Value

One gram of oil was refluxed with 25 mL of 0.5 N ethanolic KOH for 60 min. After cooling, the excess alkali was titrated against standardized 0.5 N HCl using phenolphthalein as the indicator.

The saponification value was calculated using:

$$SV = \frac{(B - S) \times N \times 56.1}{W}$$

where

B = Blank titre

S = Sample titre

N = Normality of HCl

W = Weight of sample (g).[6]

### 2.4 Preparation of Polyherbal Gel

Carbopol 934 (1% w/w) was dispersed in distilled water and allowed to hydrate for 1 h. Glycerin was added with continuous stirring, followed by methyl paraben and EDTA until complete dissolution. Tween 80 was incorporated to facilitate emulsification.

Separately, linseed oil, sunflower oil, peppermint oil, eucalyptus oil, clove oil, rosemary oil, camphor, and turpentine oil were mixed thoroughly to obtain a uniform herbal oil phase. The oil mixture was gradually added to the hydrated Carbopol gel with continuous mechanical stirring.

Finally, triethanolamine was added dropwise to neutralize the dispersion and adjust the pH to approximately 5.5–6.5, resulting in the formation of a smooth, homogeneous polyherbal gel.[7–9]

### 2.5 Formulation Design

Six formulations (F1–F6) were prepared by varying the concentrations of herbal oils and excipients while maintaining Carbopol 934 as the gelling polymer.

**Table 2. Composition of polyherbal gel formulations**

| Ingredients | Formulation 1 | Formulation 2 | Formulation 3 | Formulation 4 | Formulation 5 | Formulation 6 |
|---|---|---|---|---|---|---|
| Linseed oil | 5.5% | 5.8% | 6.1% | 5.7% | 6.8% | 6.3% |
| Sunflower oil | 6.2% | 6.6% | 7.1% | 6.2% | 7.2% | 7.0% |
| Peppermint oil | 6.5% | 6.0% | 5.5% | 6.1% | 6.2% | 6.9% |
| Eucalyptus oil | 3.2% | 3.5% | 3.8% | 4.2% | 4.8% | 3.7% |
| Glycerin | 4.8% | 5.2% | 3.9% | 6.2% | 7.1% | 7.3% |
| Clove oil | 0.4% | 0.6% | 0.9% | 1.2% | 1.5% | 1.8% |
| Turpentine oil | 0.25% | 0.27% | 0.17% | 0.25% | 0.25% | 0.25% |
| Rosemary oil | 1.5% | 2.0% | 1.3% | 1.5% | 1.1% | 1.3% |
| Carbopol 934 | 1.6% | 1.4% | 1.3% | 0.6% | 1.0% | 1.2% |
| Camphor | 3.5% | 2.4% | 3.2% | 3.6% | 4.5% | 4.9% |
| Tween 80 | 4.3% | 3.5% | 3.0% | 3.8% | 4.3% | 4.3% |
| Methyl paraben | 0.2% | 0.2% | 0.2% | 0.2% | 0.3% | 0.3% |
| E.D.T.A. | 0.07% | 0.05% | 0.08% | 0.07% | 0.09% | 0.07% |
| Triethanolamine | 3.4% | 3.5% | 4.4% | 4.6% | 4.8% | 4.9% |
| Water | Q.S. | Q.S. | Q.S. | Q.S. | Q.S. | Q.S. |

### 2.6 Evaluation of Polyherbal Gel

The prepared formulations were evaluated for physicochemical and performance characteristics.

#### 2.6.1 Physical Appearance

The gels were visually examined for color, homogeneity, consistency, phase separation, and odor.

#### 2.6.2 pH Determination

The pH was measured using a calibrated digital pH meter by immersing the glass electrode directly into the gel. Measurements were performed in triplicate and the average value was reported.[10]

#### 2.6.3 Spreadability

Spreadability was determined using the glass slide method. Approximately 350 mg of gel was placed between two glass slides, and a predetermined weight was applied. Spreadability was calculated using

$$S = \frac{M \times L}{T}$$

where

S = Spreadability

M = Applied weight

L = Length of glass slide

T = Time required to separate the slides.

2.6.4 Viscosity

The viscosity was measured using a Brookfield digital viscometer equipped with an appropriate spindle at 25 ± 2°C and 12 rpm. Measurements were recorded in triplicate.

#### 2.6.5 Washability

A small amount of gel was applied onto the dorsal surface of the hand and washed under running tap water. Ease of removal and residue formation were visually assessed.

### 2.6.6 Skin Irritation (Patch Test)
The prepared gel was applied to a small area (approximately 2 $cm^2$) on healthy human skin and observed for 24–48 h for erythema, edema, itching, burning, or other signs of irritation.

### 2.6.7 Stability Study
The optimized formulation was stored at room temperature (25 ± 2°C) for one month. Samples were periodically evaluated for physical appearance, pH, viscosity, spreadability, and phase separation according to ICH stability guidelines.[11]

## 3. RESULTS AND DISCUSSION
### 3.1 Physicochemical Characterization of Extracted Oils
The extracted linseed and sunflower oils were characterized by determining their acid value and saponification value as preliminary quality control parameters. The acid value of linseed oil was found to be 3.6 mg KOH/g**,** whereas sunflower oil exhibited a lower acid value of 1.3 mg KOH/g, indicating minimal free fatty acid content and good quality of the extracted oils. The saponification values of linseed oil and sunflower oil were 192.25 mg KOH/g **and** 189.36 mg KOH/g, respectively, suggesting the presence of fatty acids with relatively low molecular weight and confirming their suitability for topical formulation development. These values are consistent with pharmacopeial limits reported for vegetable oils and indicate that the extraction process preserved the physicochemical integrity of the oils.

Suggested Table 1
**Table 1. Physicochemical properties of extracted oils**

| Parameter | Linseed Oil | Sunflower Oil |
|---|---|---|
| Acid value (mg KOH/g) | 3.6 | 1.3 |
| Saponification value (mg KOH/g) | 192.25 | 189.36 |

### 3.2 Evaluation of Polyherbal Gel Formulations
Six polyherbal gel formulations (F1–F6) were successfully prepared using Carbopol 934 as the gelling polymer. The formulations differed in the concentration of herbal oils and excipients to obtain an optimized gel with desirable physicochemical properties. All formulations exhibited a smooth texture without evidence of phase separation, indicating good compatibility among the herbal ingredients and excipients. The gels possessed a pleasant herbal odor and white appearance, which may improve patient acceptability during topical application.

### 3.3 Physical Appearance
Visual inspection revealed that all formulations were homogeneous and free from coarse particles or grittiness. No evidence of syneresis or phase separation was observed during preparation or after storage, demonstrating satisfactory physical stability. The presence of Carbopol 934 produced a smooth gel matrix with uniform consistency.

**Table 2: Physical characteristics of prepared gels**

| Formulation | Color | Odor | Homogeneity | Consistency | Phase Separation |
|---|---|---|---|---|---|
| F1 | White | Pleasant | Good | Good | Nil |
| F2 | White | Pleasant | Good | Good | Nil |
| F3 | White | Pleasant | Good | Good | Nil |
| F4 | White | Pleasant | Good | Good | Nil |
| F5 | White | Pleasant | Excellent | Excellent | Nil |
| F6 | White | Pleasant | Good | Good | Nil |

### 3.4 pH Determination
The pH of topical formulations is a critical quality attribute that influences skin compatibility, formulation stability, and patient acceptability. The normal physiological pH of healthy human skin ranges from **4.5 to 6.5**, and topical formulations within this range are less likely to cause skin irritation or disruption of the skin barrier. The pH of the prepared polyherbal gel formulations was determined using a calibrated digital pH meter, and the optimized formulation (F5) exhibited a pH of 6.2 ± 0.03 (mean ± SD, $n$ = 3), which lies within the acceptable physiological range for topical application.

The observed pH indicates that the formulation is compatible with the skin and is unlikely to produce irritation, erythema, or discomfort upon application. The appropriate pH was achieved by careful adjustment with

triethanolamine during gel preparation, which neutralized Carbopol 934 and produced a stable gel matrix. Furthermore, no appreciable change in pH was observed during the one-month stability study, indicating the chemical stability of the formulation and the absence of significant degradation or interaction among the incorporated herbal oils and excipients.

Comparable pH values have been reported for Carbopol-based herbal gels developed for topical analgesic and anti-inflammatory applications, typically ranging between 5.5 and 6.5, supporting the suitability of the present formulation for dermal administration. Therefore, the optimized formulation (F5) demonstrated satisfactory pH characteristics, confirming its potential as a safe and stable topical herbal gel.

| Formulation | pH (Mean ± SD, n = 3) |
|---|---|
| F1 | 5.81 ± 0.04 |
| F2 | 5.94 ± 0.03 |
| F3 | 6.05 ± 0.02 |
| F4 | 6.12 ± 0.05 |
| F5 | 6.20 ± 0.03 |
| F6 | 6.18 ± 0.04 |

### 3.5 Spreadability
All formulations demonstrated satisfactory spreadability, indicating ease of application over the skin surface. Good spreadability facilitates uniform distribution of the gel, thereby improving patient compliance and ensuring adequate contact between the formulation and the affected area. Among the prepared formulations, F5 exhibited superior spreadability compared with the remaining batches.

### 3.6 Viscosity
Viscosity is an essential parameter governing the residence time and ease of application of topical gels. The prepared formulations exhibited acceptable viscosity suitable for topical administration. A proper viscosity ensures sufficient retention of the gel at the application site without excessive runoff. The optimized formulation maintained its viscosity after storage, indicating good physical stability.

### 3.7 Washability
The prepared polyherbal gels were easily removed with water and did not leave oily residues on the skin. This property enhances user convenience and supports routine clinical use.

### 3.8 Skin Irritation (Patch Test)
No erythema, itching, edema, burning sensation, or other visible signs of irritation were observed following topical application of the formulations, indicating that the prepared gels were non-irritant under the conditions of the study. The presence of herbal oils together with an appropriate gel base contributed to acceptable skin compatibility.

### 3.9 Stability Study
The optimized formulation was stored at room temperature for one month and periodically evaluated. No significant changes were observed in physical appearance, pH, spreadability, viscosity, or homogeneity during storage, indicating satisfactory physical stability. Based on the overall evaluation, formulation F5 demonstrated better stability and overall performance than the remaining formulations.

**Table No. 3: Summary of Analgesic Anti-inflammatory Gel**

| Sr. No. | Test | Result |
|---|---|---|
| 1 | Color | White |
| 2 | Homogeneity | Homogenous |
| 3 | Consistency | Good |
| 4 | Odor | Pleasant |
| 5 | pH | 6.2 |
| 6 | Spreadability | Excellent |
| 7 | Viscosity | Acceptable |

## CONCLUSION
The present study successfully formulated and evaluated a polyherbal topical gel containing linseed (*Linum usitatissimum*) oil, sunflower (*Helianthus annuus*) oil, peppermint oil, eucalyptus oil, clove oil, rosemary oil,

camphor, and turpentine oil using Carbopol 934 as the gelling agent. The extracted seed oils exhibited acceptable physicochemical characteristics, confirming their suitability for incorporation into topical formulations. Six gel formulations (F1–F6) were prepared and evaluated for physicochemical properties, including appearance, homogeneity, pH, spreadability, viscosity, washability, patch test, and stability. All formulations demonstrated satisfactory characteristics with good homogeneity, pleasant odor, acceptable viscosity, excellent spreadability, and no evidence of phase separation or skin irritation.

Among the prepared formulations, **F5** exhibited the most desirable physicochemical properties and maintained satisfactory stability throughout the storage period, indicating its suitability as the optimized formulation. The results suggest that the developed polyherbal gel possesses appropriate physicochemical attributes for topical application and represents a promising herbal delivery system for localized skin application. However, further investigations, including in vitro drug release, skin permeation studies, pharmacological evaluation of analgesic and anti-inflammatory activity, long-term stability studies, and clinical investigations, are required to establish its therapeutic efficacy and safety before potential clinical use.

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