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Formulation, Development and Evaluation of Herbal Oil for Arthritis

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Abstract: -

Arthritis is a chronic musculoskeletal disorder characterized by joint pain, inflammation, stiffness, and reduced mobility, which significantly affects the quality of life of patients. Conventional pharmacological therapies such as non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids provide symptomatic relief but are associated with adverse effects during prolonged use. Hence, the development of safer and effective herbal alternatives for topical therapy has gained considerable attention. The present study aimed to formulate and evaluate a herbal oil for the management of arthritis using medicinal plants such as Withania somnifera (Ashwagandha), Semecarpus anacardium (Khandu Chakka), Argyreia speciosa (Samudra Vel), Piper betle (Nagvel), and Piper nigrum (Black pepper), with mustard oil used as the base oil. Six formulations (F1–F6) were prepared by incorporating different essential oils including eucalyptus oil, eugenol oil, sesame oil with eucalyptus oil, mentha crystal oil, camphor oil, and castor oil with eugenol oil.

The prepared formulations were evaluated for physicochemical parameters such as appearance, pH, density, viscosity, acid value, saponification value, ester value, and skin penetration using agar gel diffusion method. All formulations showed acceptable physicochemical properties with pH ranging from 6.2–6.8, density 0.80–0.95, viscosity 2.0–2.62 poise, acid value 2.0–2.4, saponification value 180–190, and ester value 158–188. Among all batches, formulation F1 containing eucalyptus oil demonstrated superior characteristics with excellent skin penetration. All values were within acceptable limits according to Indian Pharmacopoeia standards. Formulation F1 was identified as the optimized formulation and may serve as a safe, effective topical therapeutic option for arthritis management.

Keywords: -Arthritis, Herbal oils, analgesics/therapeutic use, Anti-inflammatory, Complementary therapy, Topical application

1. Introduction: -

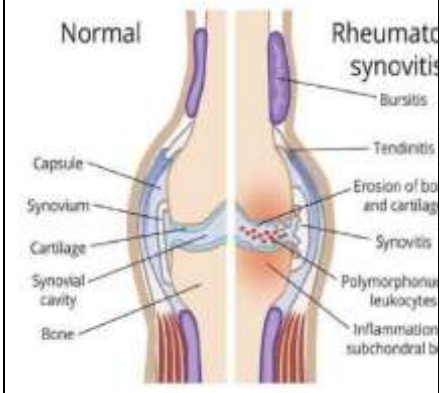
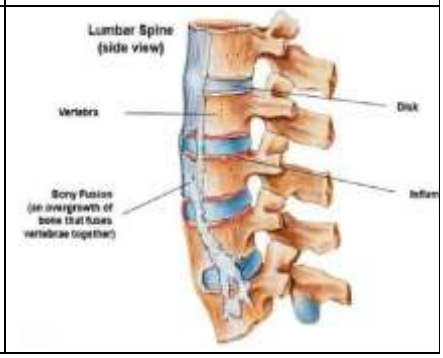
Arthritis is a prevailing chronic health issue and a major contributor to disability. The Greek word “arthritis” is derived from the root words “arthron” and “ites” meaning “inflammation of joints”. Arthritis is a long-term, inflammatory,

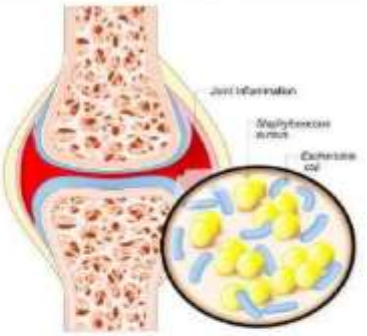
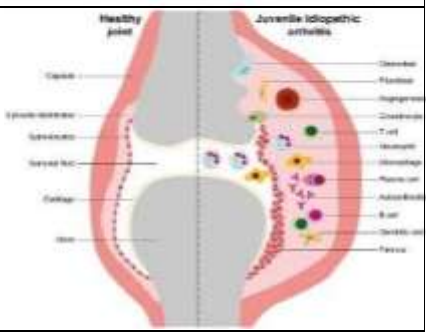
systemic autoimmune disease that causes stiffness, swelling and pain in the joints. Arthritis is the medical term for swelling or inflammation of the joints. It depicts various ailments that have an impact on connective tissues, joints, and surrounding tissues.

[1]

1.1Types of Arthritis – Definitions, Causes, Symptoms: - [2-9] Table-1

1. Rheumatoid arthritis (RA)
2. Osteoarthritis (OA)
3. Psoriatic Arthritis (PsA)
4. Ankylosing Spondylitis (AS)
5. Gout
6. Pseudogout (Calcium Pyrophosphate Deposition Disease – CPPD)
7. Septic Arthritis
8. Juvenile Idiopathic Arthritis (JIA)

Sr. No.	Type of Arthritis	Definition	Causes	Symptoms	Image
1	Rheumatoid Arthritis (RA)	Chronic, systemic autoimmune disorder that targets synovial joints, causing pannus, cartilage destruction, and bone erosion; symmetrical involvement.	• Autoimmune dysregulation (Tcell, B-cell, TNF-α, IL-6) • Genetic predisposition (HLA-DRB1) • Smoking, infections • Hormonal factors (common in women)	• Symmetrical polyarthritis • Morning stiffness >1 hr. • Swelling, tenderness, warmth • Fatigue, fever, weight loss • Nodules, lung/eye issues	
2	Osteoarthritis (OA)	Degenerative joint disease with cartilage loss, subchondral bone remodeling, osteophytes; noninflammatory, age-related.	• Aging, wear & tear • Obesity • Repetitive strain/trauma • Genetic factors • Metabolic syndrome	• Pain ↑ with activity, ↓ with rest • Morning stiffness <30 min • Crepitus • Limited movement • Bony enlargements (Heberden's, Bouchard's)	
3	Psoriatic Arthritis (PsA)	Chronic immunemediated arthritis linked to psoriasis; seronegative spondyloarthropathy.	• Autoimmune dysregulation • Genetic (HLAB27, HLA-Cw6) • Environmental triggers • Pre-existing psoriasis	• Asymmetric oligoarthritis • Dactylitis ("sausage digits") • Enthesitis • Nail pitting, onycholysis • Spinal involvement	
4	Ankylosing Spondylitis (AS)	Chronic inflammatory arthritis of sacroiliac joints & spine → stiffness, "bamboo spine."	• Genetic (HLA-B27, ERAP1) • IL-17/TNF dysregulation • Gut microbiome	• Low back pain better with activity • ↓ spinal mobility • Hip/shoulder arthritis • Uveitis, IBD, cardiac issues	

5	Gout	Crystal-induced arthritis from urate crystal deposition due to hyperuricemia.	• Hyperuricemia • High purine diet • Obesity, metabolic syndrome • Renal impairment • Drugs (diuretics, cyclosporine)	• Acute pain (big toe – podagra) • Redness, swelling, warmth • Tophi (chronic) • Kidney stones	
6	Pseudogo ut (CPPD)	Arthritis from calcium pyrophosphate crystal deposition in cartilage/synovi um.	• Aging • Metabolic disorders • Trauma/surgery • Genetic predisposition	• Sudden swelling (knee, wrist, large joints) • OA/RA-like chronic pain • Limited mobility • Rhomboid crystals in synovial fluid	
7	Septic Arthritis	Acute bacterial/viral/fu ngal joint infection → rapid destruction; medical emergency.	• Hematogenous spread • Trauma, surgery, injections • Diabetes, RA, immunosuppressio n	• Severe pain, swelling, warmth • Fever, systemic infection • Restricted motion • Purulent synovial fluid, ↑WBC	
8	Juvenile Idiopathic Arthritis (JIA)	Chronic arthritis of unknown cause, starting <16 yrs, lasting ≥6 weeks.	• Autoimmune dysregulation • Genetic predisposition • Infections, stress	• Joint pain, stiffness, swelling • Fever & rash (systemic JIA) • Uveitis • Growth disturbances & deformities	

Herbal oil: Herbal oils are emerging as natural alternatives due to their anti- inflammatory, analgesic, and antioxidant properties. Oils like ginger, lavender, black cumin seed, and basil have shown benefits in reducing pain and improving mobility in arthritis patients. These oils are often applied topically or used in massage therapy, offering potential relief with fewer adverse effects.

[10]

Fig 1-Arthritis Roll-On

Arthritis is a painful swelling of joints and it is a common disease affecting large population. Osteoarthritis and rheumatoid arthritis are most common. Osteoarthritis is a degenerative joint disease occurring chiefly in older people and rheumatoid arthritis is an autoimmune disorder of unknown etiology. In complementary and alternative medicines such as Ayurvedic (herbs) are most commonly used for the treatment of many systemic disorders

1.2Arthritis is most common in the following areas of the body-

- Feet
- Hands
- Hips
- Knees

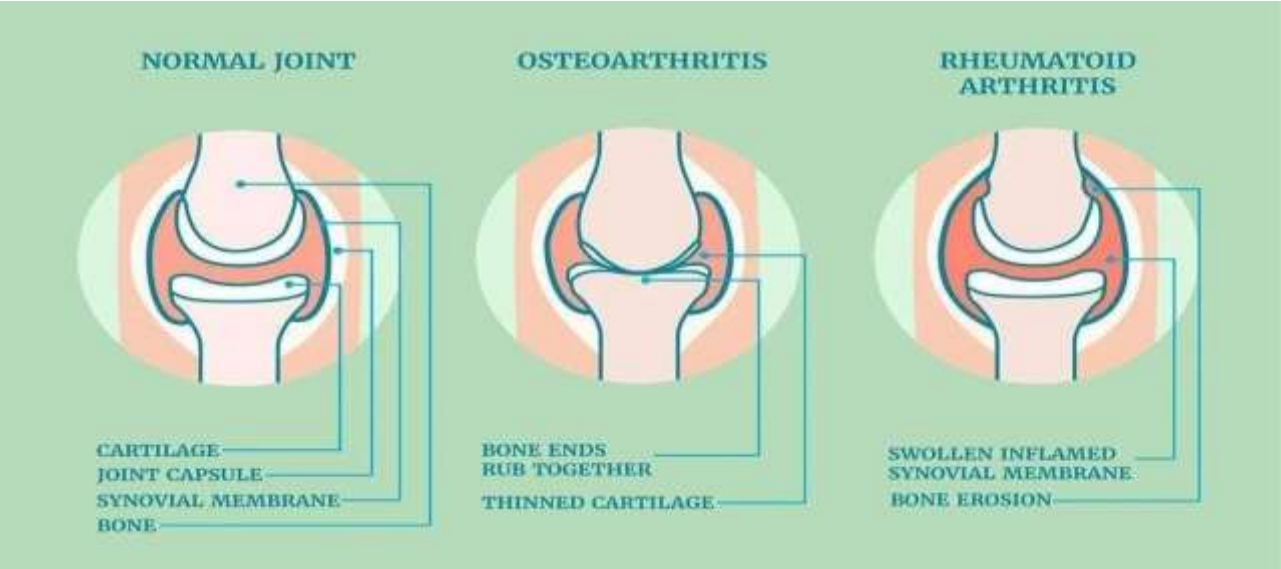
Usually, when a bone moves or twists on similar pieces to maintain the functional flexibility, it is then characterized as a joint. During movement the ligaments act as elastic bands to help keep the bones in the same place.

Under all situations whether in resting or moving, ligaments always hold them at the same place. Cartilage tissue covers the bone surfaces to prevent from direct rubbing thus smoothens the limb movement without causing pain or bone erosion due to friction. The cavity inside the joint is filled with synovial fluid produced by the cells from the synovial membrane which is aligned with the ligaments within the joint cavity. In case of arthritis, primarily the suffering starts due to faulty joints. [11]

Herbal oils are traditional cosmetic aids and herbal remedies used to nourish and revitalize the skin and treat skin conditions. Beneficial effects are achieved through the combination of nutrients, antioxidants and bio stimulants extracts from herbs with vegetable oil. Herbal oil extracts are produced by repetitive extraction of raw herbs into vegetable oils in conditions optimized for preservation of herbal antioxidants, stimulants and nutrients. The process is similar to the one used for alcohol extracts, only vegetable oil is used instead of alcohol. However, herbal oils utilized in traditional herbal medicine are all obtained with vegetable oil extraction, the only available method at those times. [12]

Fig 2 - Rheumatoid Arthritis vs. Osteoarthritis Joint Pain by Beth Levine

1.3Advantages of Herbal Oils:



1. Significantly reduces knee joint pain in osteoarthritis patients.
2. Helps decrease stiffness and improves joint mobility.
3. Enhances physical function and walking ability.
4. Produces a soothing and warming effect after application.
5. Found to be safe and well tolerated with no serious adverse effects. [13]
6. Anti-inflammatory and Pain-Relieving Action.
7. Safer Alternative to Long-Term NSAIDs. [14]

1.4Disadvantages of Herbal Oils:

1. Lack of standardized formulations makes results inconsistent across studies.
2. Most trials are small and short-term, limiting reliability of findings.

3. Insufficient safety data on long-term use and possible side effects.
4. Reported improvements may be influenced by placebo effects or massage itself.
5. Quality control issues exist due to unregulated herbal oil preparations. [15]
6. Skin Irritation & Hypersensitivity.
7. Improper Use Increases Risk
8. Myth of "Natural = Safe". [16]

2. Plant profile: [17-20] Table-2

Feature	Vitex negundo (Nirgundi)	Piper betle (Nagveli)	Elephant Creeper (Samudra vel)	Black Pepper (Piper nigrum)
Synonyms	Nirgundi, Five-leaved chaste tree	Betel leaf, Nagveli	Samudra vel, Elephant creeper	Black pepper, Kali mirch
Biological Source	Leaves of Vitex negundo Linn.	Leaves of Piper betle Linn.	Leaves of Argyreia nervosa	Dried fruits of Piper nigrum Linn.
Family	Lamiaceae	Piperaceae	Convolvulaceae	Piperaceae
Part Used	Fresh or dried leaves	Fresh leaves	Leaves	Dried fruits (peppercorns)
Colour	Green leaves	Bright green leaves	Dark green leaves	Black to brown
Odour	Aromatic, herbaceous	Strong aromatic	Mild herbal odour	Aromatic, spicy
Taste	Bitter, pungent	Pungent, spicy	Slightly bitter	Hot, pungent
Major Chemical Constituents	Flavonoids, iridoid glycosides, essential oils	Eugenol, chavibetol, flavonoids	Alkaloids, flavonoids, glycosides	Piperine, volatile oils
Pharmacological Actions	Anti-inflammatory, analgesic, antioxidant	Antimicrobial, analgesic, circulation stimulant	Anti-inflammatory, anti-swelling	Warming stimulant, bioavailability enhancer
General Uses	Joint pain relief, swelling reduction, muscle relaxation	Pain relief, improves local circulation	Reduces swelling and chronic pain	Improves absorption and warming relief
Use in Herbal Oil for Arthritis	Reduces inflammation, stiffness, and pain; improves mobility	Enhances oil penetration and relieves joint pain	Helps reduce swelling and chronic joint discomfort	Provides warming effect and improves circulation
Safety Notes	Generally safe in topical use	Safe externally; avoid excessive internal use	Traditionally safe when used topically	Use in moderate topical amounts
Images				

3. Aim: -

To Formulation, Development and Evaluation of Herbal Oil for Arthritis using natural ingredients for the effective relief of arthritis pain.

4. Objective: -

- To identify and select medicinal plants and herbal drugs traditionally used for the treatment of arthritis.
- To prove the pharmacological properties of selected herbal drugs such as anti-inflammatory, analgesic, and antioxidant activities.
- To select a suitable base oil (such as sesame oil, coconut oil, or mustard oil) for better absorption and therapeutic effect.
- To prepare herbal oil using appropriate extraction or infusion methods.
- To evaluate the therapeutic effect of the herbal oil in relieving joint pain, swelling, and stiffness.
- To study the role of essential oils (such as eucalyptus oil, peppermint oil, clove oil, etc.) in enhancing the anti-inflammatory activity of the formulation.
- To compare the effectiveness of the herbal oil with conventional topical analgesic preparations.
- To determine the safety and skin compatibility of the herbal oil formulation.
- To promote the use of natural herbal drugs as safer alternatives to synthetic antiinflammatory drugs.

5. EXPERIMENTAL WORK:

Material used: Table-3

SR. NO	Material	Supplier (Industry Name with Location)
1	Withania somnifera (Ashwagandha)	Local Ayurvedic raw material supplier / Herbal drug store
2	Khandu Chakka (Semecarpus anacardium)	Local crude drug supplier / Ayurvedic raw material market
3	Elephant Creeper (Argyreia speciosa) [Samudra Vel]	Herbal raw material supplier / Ayurvedic medicine store
4	Piper betle (Betel leaf) [Nagveli]	Local herbal supplier / Ayurvedic drug store
5	Black Pepper (Piper nigrum)	Local spice supplier / Herbal raw material market
6	Eucalyptus Oil	Essential oil supplier / Pharmaceutical raw material supplier
7	Eugenol Oil (Clove Oil)	Essential oil supplier / Pharmaceutical raw material supplier
8	Sesame Oil (Sesamum indicum)	Ayurvedic oil supplier / Herbal raw material supplier
9	Mentha Crystal (Menthol)	Essential oil supplier / Pharmaceutical raw material supplier
10	Camphor Oil	Essential oil supplier / Pharmaceutical raw material supplier
11	Castor Oil (Ricinus communis)	Ayurvedic oil supplier / Herbal raw material supplier

Instruments used: Table-4

Sr. No.	Equipment	Source
1	Digital Weighing Balance	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
2	Mortar and pestle	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
3	Water Bath	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
4	Digital pH Meter	Pharmaceutical Analysis Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
5	Round Bottom Flask	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
6	Reflux Condenser	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
7	Autoclave	Microbiology Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
8	Laboratory Gas Burner	Pharmaceutics Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India
9	Petri Dish	Microbiology Laboratory, P. W. College of Pharmacy, Yavatmal, Maharashtra, India

6. Procedure for herbal oil formulation:

1. Collection and Cleaning

• Fresh, healthy, and disease-free plant materials such as Withania somnifera roots, Khandu chakka leaves, elephant creeper (Samudra vel) leaves, Piper betle (Nagveli) leaves, and black pepper are collected in required quantities.

• All materials are washed thoroughly with clean running water to remove dust, soil, and impurities.

• The cleaned materials are allowed to dry to remove excess surface moisture.

2. Grinding (Size Reduction)

• Cleaned plant materials are taken in appropriate proportions.

• Materials are ground using a traditional grinding stone or mechanical grinder.

• Grinding is continued until a coarse, uniform paste is obtained.

• This step increases surface area and enhances extraction of active phytoconstituents.

3. Maceration (Resting Process)

• The prepared herbal paste is transferred into a clean, dry container.

• It is kept undisturbed for 48 hours under natural conditions.

• During this period, plant tissues soften and release bioactive compounds.

• This improves extraction efficiency during heating.

4. Heating Process (Extraction in Oil)

• The macerated paste is mixed with mustard oil in a suitable vessel.

• The mixture is heated on a low flame.

• Continuous stirring is done to ensure uniform heating and prevent charring.

• Heating is continued until moisture completely evaporates.

• Oil becomes clear, free from froth, and slightly viscous.

• Residue becomes dry, indicating complete extraction of active constituents.

5. Filtration and Storage

• The prepared oil is allowed to cool to room temperature.

• Oil is filtered using a clean muslin cloth to remove solid residues.

• Clear filtrate is collected carefully.

• The oil is stored in a clean, dry, airtight container to maintain quality and stability.

Core Formula: Table-5

Sr. No.	Ingredient	Quantity Used
1	Withania somnifera (Ashwagandha)	125 g
2	Khandu Chakka	21 leaves
3	Elephant Creeper (Samudra Vel)	21 leaves
4	Piper betel (Nagvel)	11 leaves
5	Black Pepper (Piper nigrum)	10–12 seeds
6	Mustard Oil	1 L

Different batches of herbal oil formulation: Table-6

Batches	Core Formula (Herbal Oil)	Oil Added	Quantity of Oil
F1	50 ml	Eucalyptus Oil	20 ml
F2	50 ml	Eugenol Oil	20 ml
F3	50 ml	Sesame Oil + Eucalyptus Oil	10 ml + 10 ml
F4	50 ml	Mentha Crystal Oil	20 ml
F5	50 ml	Camphor Oil	20 ml
F6	50 ml	Castor Oil + Eugenol Oil	10 ml + 10 ml

Evaluation of herbal oil formulations is an important step to ensure the quality, stability, and effectiveness of the prepared product. Various physicochemical tests are performed to assess the physical appearance, chemical properties, and performance of the herbal oil. These evaluation

parameters help in determining whether the formulation is safe, stable, and suitable for topical application.

7. THE EVOLUTION TEST PROCEDURE (F1–F6) [21]

The prepared herbal oil formulations were evaluated for physicochemical parameters such as appearance, pH, density, viscosity, acid value, saponification value, ester value, and skin penetration. These tests were performed to determine the quality, stability, and suitability of the formulation for topical application and to select the optimized batch.

7.1APPEARANCE / ORGANOLEPTIC EVALUATION

Introduction: -

Organoleptic evaluation involves the assessment of the formulation using the human senses. It helps to determine the physical characteristics such as colour, odor, clarity, and appearance of the herbal oil formulation.

Method: -

- Take a small quantity of herbal oil in a clean glass container.
- Observe the formulation under normal light conditions.
- Evaluate the following characteristics:
- Colour
- Odour
- Clarity
- Homogeneity
- Presence of particulate matter Significance: -

Organoleptic evaluation is a basic but important quality control test. A clear and uniform formulation indicates proper mixing of ingredients and physical stability. Any change in colour, turbidity, or unpleasant odour may indicate instability, contamination, or degradation of the formulation.

7.2DENSITY / SPECIFIC GRAVITY

Introduction:

Density or specific gravity is defined as the ratio of the weight of a given volume of oil to the weight of an equal volume of water.

Method: -

- Take a clean and dry specific gravity bottle.
- Weigh the empty bottle.
- Fill the bottle with herbal oil formulation and weigh again.
- Compare the weight with an equal volume of distilled water.
- Calculate the specific gravity value. Formula: -

Specific Gravity = $(W_2 - W_1) / (W_3 - W_1)$ Where:

W_1 = Weight of empty bottle W_2 = Weight of bottle + oil W_3 = Weight of bottle + water Significance: -

Specific gravity helps determine the purity and uniformity of the formulation. It also provides information about the composition and consistency of the herbal oil.

7.3pH DETERMINATION

Introduction: -

pH determination is used to evaluate the acidity or alkalinity of the formulation. It is important to ensure that the formulation is compatible with the skin.

Method: -

- Take a small quantity of herbal oil formulation.
- Mix it with distilled water.
- Calibrate the digital pH meter using standard buffer solutions.
- Measure the pH of the sample using the pH meter.
- Record the pH value. Formula: - pH value is obtained directly from the digital pH meter. Significance: -

The pH of a formulation plays an important role in determining skin compatibility. A suitable pH helps prevent skin irritation and ensures the stability of the formulation during storage.

7.4VISCOSITY

Introduction: -

Viscosity refers to the resistance of a liquid to flow. It indicates the thickness and flow behavior of the herbal oil formulation.

Method: -

- Take the herbal oil sample in a viscometer container.
- Place the container in a Brookfield viscometer.
- Select the appropriate spindle.
- Measure the viscosity at room temperature.
- Record the viscosity reading. Formula: -

Viscosity = Dial reading × Factor (Unit: centipoise, cP) Significance:

Viscosity determines the spreadability and ease of application of the herbal oil on the skin. Proper viscosity ensures that

the formulation can be easily applied and evenly distributed.

7.5ACID VALUE

Introduction:

Acid value indicates the amount of free fatty acids present in the oil. It helps determine the quality and degree of rancidity of the formulation.

Method: -

- Take a known quantity of oil in a conical flask.
- Add alcohol–ether mixture to the sample.
- Add a few drops of phenolphthalein indicator.
- Titrate with 0.1 N potassium hydroxide solution.
- Continue titration until a light pink color appears. Formula: -

Acid Value = (V × N × 56.1) / W Where: -

V = Volume of KOH used (ml) N = Normality of KOH

W = Weight of oil sample (g) Significance: -

Acid value indicates the presence of free fatty acids in the oil. A high acid value may indicate deterioration or hydrolysis of fats, which affects the quality and stability of the formulation.

7.6SAPONIFICATION VALUE

Introduction: -

Saponification value represents the amount of alkali required to saponify fats and oils present in the formulation.

Method: -

- Take a known quantity of oil sample.
- Add alcoholic potassium hydroxide solution.
- Heat the mixture under reflux.
- Titrate the excess alkali with hydrochloric acid.
- Use phenolphthalein as an indicator. Formula: -

Saponification Value = ((B − S) × N × 56.1) / W Where:

B = Volume of HCl used for blank (ml) S = Volume of HCl used for sample (ml) N = Normality of HCl

W = Weight of oil sample (g) Significance: -

Saponification value provides information about the average molecular weight of fatty acids present in the oil and helps determine the composition of the formulation.

7.7ESTER VALUE

Introduction: -

Ester value represents the amount of ester compounds present in the oil. Method: -

- Determine the acid value of the oil sample.

- Determine the saponification value.
- Calculate ester value using the formula. Formula: -

Ester Value = Saponification Value − Acid Value.

Significance: -

Ester value helps evaluate the chemical composition and quality of the oil. It indicates the amount of esterified fatty acids present in the formulation.

7.8SKIN PENETRATION (AGAR GEL DIFFUSION METHOD)

Introduction: -

Skin penetration study is used to evaluate the ability of the herbal oil formulation to penetrate through a semi-solid medium similar to skin.

Method: -

- Prepare agar gel and pour it into Petri dishes.
- Allow the gel to solidify.
- Make small wells in the gel using a sterile borer.
- Add the herbal oil formulation into the wells.
- Incubate and observe the diffusion of the formulation. Formula: -

Diffusion Area = πr^2 Where:

r = Radius of diffusion zone Significance: -

This test helps determine the ability of the formulation to penetrate through the skin and deliver active ingredients effectively. Good penetration ensures better therapeutic activity of the herbal oil.

The evaluation parameters carried out in this study are important for determining the physicochemical characteristics, stability, and overall quality of the herbal oil formulation. The results obtained from various tests such as organoleptic properties, density/specific gravity, pH, viscosity, acid value, saponification value, ester value, and skin penetration study showed that the prepared formulations possess satisfactory physical properties and good stability. These findings indicate that the formulation meets the required pharmaceutical standards and is suitable for topical application, ensuring quality, safety, and patient acceptability.

8. Results and Discussion: -

8.1General Observation of Formulations (F1–F6)

- All formulations showed acceptable physicochemical properties suitable for topical application.
- No phase separation or instability was observed, indicating good formulation design.
- Colour variation (yellow to greenish-yellow) is due to the natural constituents of different oils.
- According to IP, formulations should be homogeneous and free from phase separation; all formulations satisfied these requirements.

8.2Appearance (Colour)

- F1 (Eucalyptus oil) showed yellowish colour, indicating purity and absence of degradation.
- Slight greenish colour in F4 (Mentha) suggests presence of menthol crystals.
- No abnormal turbidity observed → confirms formulation stability.
- According to IP, formulations should be clear and free from turbidity; all formulations complied with this standard.

8.3pH Evaluation

- All formulations had pH in the range 6.2–6.5, which is close to skin pH (~5.5–7).
- F1 and F3 (6.5) are slightly closer to neutral → less chance of irritation.
- Suitable pH ensures safe topical application for arthritis patients.
- According to IP, acceptable pH range for topical preparations is 5.5–7.0; the observed values were within the prescribed limits.

8.4Density / Specific Gravity

- Values ranged from 0.80–0.90, indicating all oils are light and easily spreadable.
- F1 showed slightly higher density (0.90), which helps in better skin adherence.
- Lower density oils (F3, F4) may spread faster but may not stay longer on skin.
- According to IP, specific gravity for fixed oils should be 0.80–0.95; observed values were within acceptable limits.

8.5Viscosity

- F1 showed highest viscosity (2.62 poise) among all formulations.
- High viscosity →
- Better retention on skin
- Prolonged contact time
- Improved drug absorption
- Very low viscosity (F2, F6) may lead to quick runoff and reduced effectiveness.
- According to IP, viscosity should be optimum for proper application, and all formulations showed suitable viscosity.

8.6Acid Value

- Acid values ranged from 2.0–2.4, indicating low free fatty acid content.
- F1 and F3 (2.0) showed better stability and less rancidity.
- Higher acid value (F5) may indicate slight degradation tendency.
- According to IP, acid value should not be more than 4.0; all values were within acceptable

limits.

8.7Saponification Value

- Values ranged from 185–190, indicating presence of fatty acids with good molecular weight.
- F1 and F2 showed highest value (190) → better emulsification and absorption potential.
- Slight variations do not significantly affect performance.
- According to IP, saponification value should be 180–200; observed values complied with the standard range.

8.8Ester Value

- F1 showed highest ester value (188) among all formulations.
- Higher ester value →
- Greater amount of active components
- Enhanced therapeutic activity
- F6 showed lowest value → comparatively less effectiveness.
- According to IP, no specific limit is prescribed for ester value, but higher values indicate better efficacy.

8.9Skin Penetration (Agar Gel Diffusion Test)

- F1 showed "Very Good" penetration, highest among all batches.
- F2, F3, F5 showed "Good" penetration.
- F4 and F6 showed "Moderate" penetration.
- Indicates that eucalyptus oil enhances transdermal delivery effectively.
- According to IP, no official limit is specified for penetration studies; comparative evaluation is acceptable

8.10 Overall Comparative Performance

- F1 (Eucalyptus oil) performed best in:
- Viscosity
- Ester value
- Skin penetration
- Stability (low acid value)
- Other formulations showed moderate to good results but lacked consistency across all parameters.
- According to IP, optimized formulation should comply with all evaluation parameters; F1

showed best overall compliance.

8.11 Reason for Better Performance of Eucalyptus Oil (F1)

- Contains eucalyptol (1,8-cineole) → strong anti-inflammatory and analgesic effect.
- Acts as a penetration enhancer, improving drug delivery through skin.
- Provides cooling and soothing effect, reducing joint pain.
- Balanced physicochemical properties → ideal for topical formulation.

8.12 Final Interpretation

Based on all evaluation parameters, F1 formulation is optimized and most effective.

It provides better stability, enhanced penetration, and superior therapeutic action, making it most suitable for arthritis treatment.

- According to IP, the optimized formulation should meet all standard limits; F1 fulfilled all criteria.

9. RESULTS: -Table-7

PARAMETERS	FORMULATION					
	F1 (Eucalyptus Oil)	F2 (Eugenol Oil)	F3 (Sesame Oil + Eucalyptus Oil)	F4 (Mentha Crystal Oil)	F5 (Camphor Oil)	F6 (Castor Oil + Eugenol Oil)
Appearance (Colour)	Yellowish	Pale Yellow	Light Yellow	Slight Greenish Yellow	Yellow	Yellowish Brown
Ph	6.5	6.3	6.5	6.2	6.4	6.3
Density / Specific Gravity	0.90	0.82	0.80	0.81	0.82	0.83
Viscosity (Poise)	2.62	1.74	1.80	2.10	2.5	1.79
Acid Value	2.0	2.3	2.0	2.2	2.4	2.3
Saponification Value	190	190	185	187	189	186
Ester Value	188	167	172	156	171	139

Skin Penetration (Agar Gel Diffusion)	Very good	Good	Good	Moderate	Good	Moderate

10. SUMMARY AND CONCLUSION:

The prepared formulation is a herbal oil for arthritis containing natural herbal ingredients with mustard oil used as the base oil. Six different batches of herbal oil were prepared by incorporating different essential oils such as Eucalyptus oil, Eugenol oil, Sesame oil + Eucalyptus oil, Mentha crystal oil, Camphor oil, and Castor oil + Eugenol oil.

The prepared formulations were evaluated based on various physicochemical parameters such as appearance, density or specific gravity, pH determination, viscosity, acid value, saponification value, ester value, and skin penetration study using agar gel diffusion method.

Based on physicochemical evaluation studies:

- Appearance of 1st batch (Eucalyptus oil) showed yellowish colour which indicates stable formulation compared to other batches.
- pH value of 1st batch was found to be 6.5, which is within suitable range for topical application and closer to skin pH.
- Density / Specific gravity of 1st batch was 0.90, indicating proper consistency and better skin adherence compared to other batches.
- Viscosity of 1st batch was 2.62 poise, showing optimum flow property and smooth spreading of oil on the skin.
- Acid value of 1st batch was 2.0, which indicates better stability and low rancidity of the formulation.
- Saponification value of 1st batch was 190, confirming the presence of fatty acids responsible for therapeutic activity.
- Ester value of 1st batch was 188, indicating better quality and higher therapeutic effectiveness.
- Skin penetration study of 1st batch showed very good penetration, indicating effective diffusion through agar gel.

On the basis of all evaluation tests such as appearance, pH, viscosity, density, acid value, saponification value, ester value and skin penetration, the Eucalyptus oil formulation (Batch 1) showed better performance compared to the other batches.

Therefore, Batch 1 containing Eucalyptus oil was found to be the optimized formulation and may be considered effective for the topical management of arthritis pain and inflammation.

11. FUTURE SCOPE:

□ Clinical Trials

– Conduct clinical studies on arthritis patients to evaluate the effectiveness of the herbal oil in reducing pain and inflammation.

□ Long-Term Stability Studies

- Perform accelerated and long-term stability studies to determine the shelf life of the formulation.

□ Dermatological Safety Testing

- Carry out skin irritation and hypersensitivity studies to ensure the formulation is safe for topical use.

□ Standardization of Raw Materials

- Standardize herbal ingredients to maintain consistent quality and therapeutic activity.

□ Pharmacological Activity Studies

- Investigate the anti-inflammatory, analgesic, and antioxidant properties through laboratory studies.

□ Comparative Study with Marketed Products

- Compare the prepared herbal oil with commercially available arthritis oils to evaluate its effectiveness.

□ Advanced Drug Delivery Systems

- Develop advanced topical formulations such as gels, creams, or ointments for improved absorption.

□ Quality Control Studies

- Establish standard quality control parameters for large-scale manufacturing.

□ Herbal Combination Research

- Explore the addition of other medicinal herbs to enhance therapeutic activity.

□ Packaging and Storage Studies

- Study suitable packaging materials to maintain stability and prevent degradation.

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