Formulation and Evaluation of Arthritis Nano-Emulsion by Using Karanja Oil

[1]Ass. Prof. Miss. Priti Ambhore, [2]Aniket Arun Shejwal, [3]Abhijeet Sunil Shinde, [4]Akanksha Dadasaheb Pendhare

[1,2,3,4]*Yashodeep Institute of Pharmacy Chh. Sambhajinagar, Maharashtra, India.*

Abstract: Arthritis is a chronic, progressive inflammatory disorder of the joints that represents one of the most prevalent and debilitating musculoskeletal conditions affecting human health worldwide. It encompasses more than 100 distinct disease entities foremost among which are osteoarthritis and rheumatoid arthritis all characterized by varying degrees of joint inflammation, pain, swelling, stiffness, and progressive structural damage that severely impair physical function and quality of life. With an estimated global prevalence of over 350 million people affected by various forms of arthritis, and no currently available cure for most forms, effective long-term management of joint inflammation and pain remains one of the most significant and persistent challenges in clinical medicine. Conventional pharmacological management of arthritis relies on non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, disease-modifying antirheumatic drugs (DMARDs), and biologic agents. While effective in controlling symptoms and slowing disease progression in many patients, these therapies are associated with serious adverse effects including gastrointestinal ulceration, cardiovascular events, renal toxicity, hepatotoxicity, and immunosuppression with prolonged use. This has generated considerable and growing interest in developing effective herbal anti-inflammatory therapeutic alternatives with superior safety profiles.

Karanja Oil the fixed oil extracted from the seeds of Pongamia pinnata Linn. (Family: Fabaceae/ Leguminosae) is a well-recognized medicinal oil in Ayurvedic and traditional medicine systems with documented anti-inflammatory, analgesic, antioxidant, and immunomodulatory properties. Its principal bioactive constituents including karanjin, pongamol, kanugin, pinnatin, and furanoflavonols have demonstrated significant inhibition of prostaglandin synthesis, COX-1 and COX-2 enzyme activity, and pro-inflammatory cytokine production

Index Terms: Karanja Oil, Pongamia pinnata, Arthritis, Nano-emulsion, Anti-inflammatory, Karanjin, Turmeric, Curcumin, Polysorbate 80, Oral Drug Delivery, Beeswax, Rheumatoid Arthritis, Osteoarthritis

I.INTRODUCTION

The word "arthritis" is derived from the Greek words arthron meaning joint and itis meaning inflammation, literally translating to inflammation of the joint a deceptively simple description for what is in reality a diverse, complex, and often devastating group of disorders that affect not merely the joint itself but the entire musculoskeletal system and, in many cases, multiple organ systems throughout the body.[3]

Arthritis and musculoskeletal disorders collectively represent the most common cause of disability in the world, surpassing even cardiovascular and respiratory diseases in terms of years lived with disability. According to the Global Burden of Disease Study, arthritis affects an estimated 350 million people globally and causes over 50 million years of disability annually. In India, the burden of arthritis is particularly significant an estimated 180 million Indians suffer from various forms of arthritis, a prevalence that exceeds that of diabetes, AIDS, and cancer combined. The economic impact of arthritis is staggering, encompassing not only direct healthcare costs for medications, physiotherapy, joint replacement surgeries, and hospitalizations, but also the enormous indirect costs of lost work productivity, caregiver burden, and reduced social participation.[3]

Fig.No.1

The pathophysiology of arthritis, while varying across its different forms, fundamentally involves an inflammatory process within the synovial joint that drives progressive degradation of cartilage, bone, tendons, and ligaments. In rheumatoid arthritis the archetypal inflammatory arthritis this process is driven by an aberrant autoimmune response in which the adaptive immune system mounts an attack against joint components, releasing pro-inflammatory cytokines including TNF-α, IL-1β, IL-6, and IL-17 that perpetuate synovial inflammation, stimulate matrix metalloproteinase (MMP) production, and drive the progressive erosion of articular cartilage and subchondral bone. In osteoarthritis the most common form the primary driver is mechanical overload and aging-related failure of cartilage homeostasis, but inflammatory mediators play an increasingly recognized and important secondary role in disease progression.[3]

The conventional pharmacological management of arthritis has been built around NSAIDs, corticosteroids, and DMARDs. While these agents provide meaningful symptomatic relief and, in the case of DMARDs and biologics, can slow or prevent structural joint damage, their long-term use is constrained by significant adverse effect profiles. NSAIDs cause gastrointestinal ulceration, bleeding, cardiovascular events, and renal impairment with chronic use. Corticosteroids cause osteoporosis, hyperglycaemia, hypertension, adrenal suppression, and increased infection risk. DMARDs such as methotrexate require regular monitoring for hepatotoxicity and bone marrow suppression. Biologic agents despite their remarkable efficacy are extremely expensive, require parenteral administration, and carry significant immunosuppression-related risks including serious infections and malignancy.[3]

This unsatisfactory risk-benefit profile of conventional antiarthritic therapy has directed considerable scientific attention toward plant-derived anti-inflammatory agents as potentially safer, more affordable, and culturally acceptable alternatives for long-term arthritis management. Among the most scientifically compelling candidates is Karanja Oil the fixed oil obtained from the seeds of Pongamia pinnata Linn. a plant that has been used in Ayurveda and traditional medicine across the Indian subcontinent for millennia for the treatment of joint pain, inflammation, and musculoskeletal disorders. [4,9]

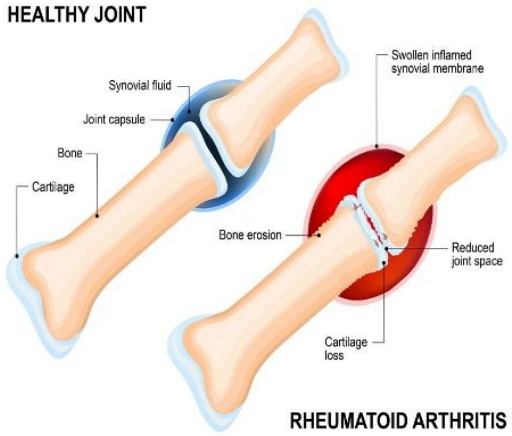


Fig.No.2

Karanja Oil is uniquely rich in Furano flavonoid compounds particularly karanjin, pongamol, and kanugin that have demonstrated potent inhibitory activity against COX-1, COX-2, and lipoxygenase enzymes, suppression of NF-κB signalling, and downregulation of pro-inflammatory cytokine production in preclinical studies. These mechanisms directly address the key inflammatory pathways operative in both rheumatoid and osteoarthritis, providing a scientifically rational basis for its therapeutic use in joint inflammation. [4,6,7]

The nano-emulsion drug delivery system offers a highly innovative and scientifically sophisticated approach to formulating Karanja Oil for oral administration. A nano-emulsion is a thermodynamically or kinetically stable colloidal dispersion of oil droplets in an aqueous continuous phase with mean droplet diameters in the range of 20–500 nm. The ultra-fine droplet size of nano-emulsions dramatically increases the interfacial surface area between oil and water phases, enhancing the solubilization capacity for lipophilic drug molecules, improving dissolution rate, promoting lymphatic absorption and systemic bioavailability, and providing long-term physical stability against creaming, sedimentation, and phase separation. [1,5,10]

The present work therefore aims to formulate and evaluate an oral Karanja Oil nano-emulsion for arthritis management, combining the potent anti-inflammatory activity of Karanja Oil with the

synergistic anti-inflammatory and antioxidant contributions of Turmeric Extract, the absorption-enhancing properties of Olive Oil, the soothing and tissue-repair benefits of Aloe Vera, and the antioxidant protection of Vitamin E all delivered in a stable, palatable, and pharmaceutically optimized nano-emulsion system.[1,6,7]

II.TYPES OF ARTHRITIS

1. Osteoarthritis (OA)
2. Rheumatoid Arthritis (RA)
3. Gouty Arthritis
4. Psoriatic Arthritis
5. Ankylosing Spondylitis
6. Juvenile Idiopathic Arthritis (JIA)
7. Infectious (Septic) Arthritis
8. Reactive Arthritis

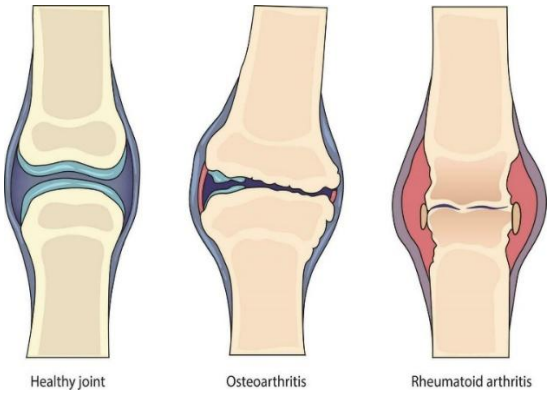


Fig.No.3

a) Osteoarthritis (OA):

Osteoarthritis is the most prevalent form of arthritis, affecting more than 500 million people globally and representing the leading cause of joint pain and disability in adults over 45 years of age. It is fundamentally a disease of articular cartilage failure the progressive breakdown of the smooth, resilient hyaline cartilage that covers the articulating surfaces of bones, reducing friction and enabling painless joint movement. OA is driven by a complex interplay of mechanical overload, aging-related decline in chondrocyte repair capacity, subchondral bone remodelling, synovial inflammation, and release of matrix-degrading MMPs and ADAMTS enzymes. Clinically, it presents as joint pain worsened by activity and relieved by rest, morning stiffness lasting less than 30 minutes, crepitus, and progressive loss of joint range of motion most commonly affecting the knees, hips, hands, and spine.[3]

b) Rheumatoid Arthritis (RA):

Rheumatoid arthritis is the most common inflammatory arthritis, affecting approximately 1% of the global population with a characteristic 3:1 female-to-male predominance. It is a systemic autoimmune disease in which the adaptive immune system mounts a sustained attack against synovial joint tissues, driven by autoreactive T and B lymphocytes responding to citrullinated self-proteins. The resulting synovial inflammation leads to formation of an invasive, destructive pannus tissue a proliferating mass of activated synoviocytes, macrophages, and fibroblasts that erodes cartilage and subchondral bone and progressively destroys joint architecture. Untreated or inadequately treated RA leads to joint deformity, significant disability, and reduced life expectancy from cardiovascular and infectious complications.[3]

c) Gouty Arthritis:

Gout is a crystal-induced inflammatory arthritis caused by the deposition of monosodium urate monohydrate (MSU) crystals in joints and periarticular tissues when serum uric acid levels chronically exceed the solubility threshold (approximately 6.8 mg/dL at physiological temperature and pH). MSU crystal deposition triggers intense acute inflammatory responses mediated by NLRP3 inflammasome activation, IL-1β release, and neutrophil infiltration producing the characteristic exquisitely painful, red, hot, and swollen joint typical of an acute gout attack. The metatarsophalangeal joint of the big toe (podagra) is the most classically affected joint. Karanja Oil's anti-inflammatory properties through COX and lipoxygenase inhibition are relevant to reducing the severity of gouty inflammation.[3]

d) Psoriatic Arthritis:

Psoriatic arthritis is a chronic, seronegative inflammatory arthritis occurring in approximately 30% of patients with psoriasis a chronic inflammatory skin disease characterized by scaly, erythematous plaques. It is driven by IL-17 and IL-23 pathway dysregulation, TNF-α overproduction, and activated dendritic cells that promote both skin and joint inflammation. Clinically, it presents with joint pain and swelling, enthesitis (inflammation at tendon and

ligament insertion points), dactylitis (sausage-shaped digit swelling), axial involvement (spondylitis), and characteristic nail changes including pitting and onycholysis.[3]

e) Ankylosing Spondylitis:

Ankylosing spondylitis is a chronic, progressive seronegative inflammatory arthritis that primarily affects the sacroiliac joints and spine, causing progressive spinal fusion and immobility. It is strongly associated with the HLA-B27 genetic allele (present in > 90% of affected individuals) and is driven by IL-17 and IL-23 mediated inflammation at entheses. Patients characteristically present with inflammatory back pain worse in the morning and with inactivity, better with exercise progressive spinal stiffness, and in advanced cases, the characteristic "bamboo spine" appearance on X-ray from syndesmophyte formation and spinal fusion.[3]

f) Juvenile Idiopathic Arthritis (JIA):

Juvenile idiopathic arthritis is an umbrella term for a heterogeneous group of chronic arthritis disorders beginning before the age of 16 years and persisting for more than 6 weeks, encompassing several distinct subtypes with different clinical presentations, laboratory findings, and outcomes. The systemic form (Still's disease) is particularly severe, presenting with spiking fever, salmon-coloured evanescent rash, lymphadenopathy, hepatosplenomegaly, and arthritis. JIA is the most common chronic rheumatic disease of childhood and can cause significant joint destruction, growth disturbances, and uveitis if inadequately treated.[3]

g) Infectious (Septic) Arthritis:

Infectious or septic arthritis results from microbial invasion of the joint space most commonly by bacteria, but also by viruses, fungi, or mycobacteria. Bacterial septic arthritis is a medical emergency that causes rapid and irreversible joint destruction within hours to days if untreated, as the combination of bacterial toxins, proteolytic enzymes released by recruited neutrophils, and increased intra-articular pressure collectively destroy cartilage and bone at a catastrophic rate. Staphylococcus aureus is the most common causative organism in adults. Treatment requires urgent joint drainage and appropriate systemic antibiotic therapy.[3]

h) Reactive Arthritis:

Reactive arthritis is a sterile, inflammatory arthritis that develops days to weeks following an infection at a remote site typically the genitourinary tract (Chlamydia trachomatis) or gastrointestinal tract (Salmonella, Campylobacter, Shigella, Yersinia). The arthritis is triggered by an immune response to bacterial antigens that cross-react with self-antigens in the joint a form of molecular mimicry. The classic triad of reactive arthritis, urethritis, and conjunctivitis is remembered by the mnemonic "Can't see, can't pee, can't climb a tree." It is also associated with HLA-B27 and may become chronic in a subset of patients.[3]

III. SYMPTOMS

1. Persistent or intermittent pain in affected joints, worsened by movement or weight-bearing Joint Pain:

2. Visible puffiness and tenderness around the joint from synovial inflammation and fluid accumulation Joint Swelling:

3. Difficulty in moving joints fully especially noticeable in the morning or after rest Stiffness and Reduced ROM:

4. Inflamed joints feel warm to the touch due to increased blood flow from inflammation Warmth and Redness:

5. Persistent tiredness particularly in autoimmune arthritis from systemic inflammation Fatigue:

6. Structural changes causing misalignment of joints in advanced inflammatory arthritis Joint Deformity:

7. Weakening of muscles surrounding affected joints due to disuse and inflammatory mediators Muscle Weakness:

Fig.No.4

Causes:

1. Aging-related deterioration of articular cartilage and reduced chondrocyte repair capacity in OA
2. Autoimmune attack on synovial joint tissues by autoreactive T and B lymphocytes in RA
3. Uric acid crystal deposition from chronic hyperuricemia causing gouty arthritis
4. Genetic predisposition HLA-B27 for ankylosing spondylitis, HLA-DRB1 shared epitope for RA
5. Obesity and mechanical overload accelerating cartilage wear and promoting pro-inflammatory adipokines
6. Joint injuries and previous trauma predisposing to post-traumatic osteoarthritis
7. Bacterial and viral infections triggering reactive arthritis or infectious arthritis
8. Dietary factors high purine intake promoting hyperuricemia and gout
9. Hormonal factors declining estragon post-menopause contributing to OA and RA susceptibility
10. Oxidative stress and free radical damage accelerating synovial inflammation and cartilage degradation

IV. PATHOPHYSIOLOGY

Rheumatoid Arthritis (RA):

1. The immune system, which normally protects the body, starts attacking the joints by mistake.
2. It targets the lining of the joints (called the synovium), causing swelling and pain.
3. Special immune cells release chemicals like TNF-α and IL-6 that increase inflammation.
4. The body also makes antibodies like rheumatoid factor (RF) that worsen the damage.
5. The inflamed lining grows into a thick layer called pannus, which damages cartilage and bone.
6. This leads to joint deformity, loss of movement, and long-term disability.
7. RA can also affect other parts of the body like the lungs, heart, and eye

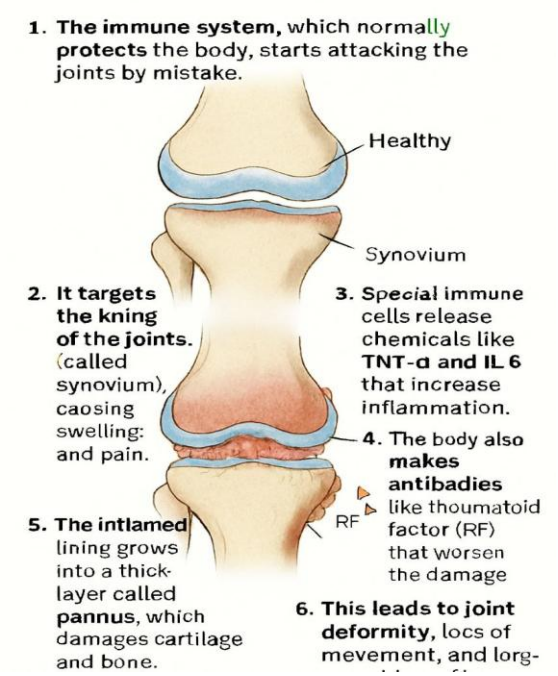


Fig.No.5

Osteoarthritis (OA):

1. The joints go through wear and tear over time due to aging, injury, or repeated use.
2. The smooth cartilage that covers the ends of bones starts to break down.
3. Without enough cartilage, bones rub against each other, causing pain and stiffness.
4. The body tries to repair the damage, but this leads to extra bone growth called bone spurs.
5. The space between the bones becomes narrow, and the joint loses flexibility
6. Mild inflammation may occur, adding to the discomfort.
7. Over time, the joint becomes stiff, painful, and harder to move.

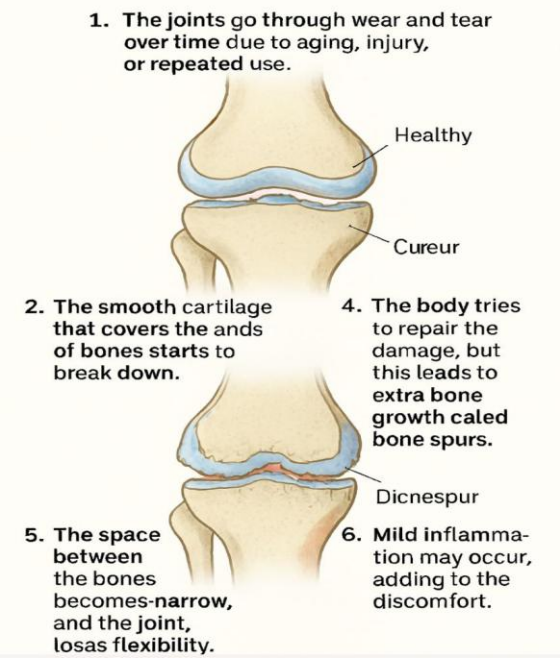


Fig.No.: 6

V.AIM AND OBJECTIVE

Aim: To develop oral Nano-emulsion using Karanja oil and herbal ingredients that helps reduce joint pain and inflammation in arthritis patients.

Objective:

i. To formulate a sweet, stable oil-in-water nano-emulsion using Karanja oil and complementary herbal extracts that masks bitterness and enhances patient acceptability.
ii. The oral nano-emulsion using Karanja oil and herbal ingredients that helps reduce joint pain and inflammation in arthritis patients.
iii. To optimized nano-emulsion's physicochemical properties—droplet size (laser diffraction), pH (pH meter), viscosity (rotational viscometer), zeta potential (electrophoretic light scattering) and confirm stability under accelerated (freeze–thaw, centrifugation) and long-term storage (25 °C/40 °C) conditions.
iv. To ensure the safety, quality, and regulatory compliance of the Karanja-based oral nano-emulsion by conducting evaluations test.

PLANOFWORK:

1) Introduction
2) Literature review
3) Selection of standard plant
4) Selection of material
5) Phytochemical screening
6) Formulation process
7) Evaluation of herbal Nano-emulsion.
8) Result and discussion
9) Conclusion
10) Reference

VI. LITERATURE SURVEY

1. Textbook of Pharmacognosy C.K. Kokate, A.P. Purohit, S.B. Gokhale Nirali Prakashan, 2020 Supports phytochemical profile, biological source, and anti-inflammatory properties of Pongamia pinnata (Karanja).
2. Essentials of Medical Pharmacology K.D. Tripathi Jaypee Brothers, 2021 Explains pathophysiology of rheumatoid and osteoarthritis and pharmacology of anti-inflammatory drugs.
3. Theory and Practice of Industrial Pharmacy Lachman L., Lieberman H.A., Kanig J.L. CBS Publishers, 2009 Covers emulsion and nano-emulsion formulation technology, stability, and evaluation.
4. Indian Pharmacopoeia Government of India IPC Ghaziabad, 2022 Standard reference for all IP grade excipients used in the nano-emulsion formulation.
5. Biopharmaceutics and Pharmacokinetics D.M. Brahmankar, S.B. Jaiswal Vallabh Prakashan, 2015 Guides bioavailability enhancement of lipophilic drugs through nano-emulsion and lymphatic absorption.
6. Herbal Drug Technology A.K. Gupta, S.S. Tandon CBS Publishers, 2020 Covers standardization, extraction, and formulation of Karanja Oil and Turmeric Extract.
7. Pharmaceutical Analysis Kasture A.V., Mahadik K.R., 2016, 17th Edition, Nirali Prakashan, Pune, pg. no. 3.1–3.22.
8. Handbook of Medicinal Plants S.S. Handa, M.K. Kaul CBS Publishers, 2021 Provides ethnobotanical and pharmacological data on Pongamia pinnata for joint pain management.

9. Pharmacognosy and Phytochemistry Vinod D. Rangari Career Publications, 2022 Details chemical constituents and anti-inflammatory activities of Karanja Oil, Turmeric, and Aloe vera.
10. Cosmetic Formulation, Manufacturing and Quality Control Sharma P.P. Vandana Publications, 2018 Covers nano-emulsion formulation principles and evaluation of herbal oil-based preparations.
11. Practical Physical Pharmacy Yadav A.V., Pawar A.Y., 2015, 1st Edition, Nirali Prakashan, Pune, pg. no. 50–75.
12. Quality Assurance Techniques in Pharmaceutical Industry Ansari S.H., 2014, CBS Publishers, New Delhi, pg. no. 90–110.

VII.MATERIAL & METHODS

MATERIAL:

Active Ingredients: Karanja Oil (Pongamia pinnata cold-pressed, pharmaceutical grade), Turmeric Extract (standardized for 95% curcuminoids).

Excipients: Olive Oil IP, Aloe Vera Gel (standardized commercial), Polysorbate 80 IP, Vitamin E (d-alpha Tocopherol), Beeswax IP (Yellow Beeswax), Citric Acid IP, Methylparaben IP, Sorbitol IP, Glycerine IP, Orange Flavour (pharmaceutical grade), Distilled Water.

Equipment: High-Shear Homogenizer / Ultra-sonicator, Magnetic Stirrer, Water Bath, Beaker, Glass Rod, Measuring Cylinders, Amber Glass Bottles, Spatula, Weighing Pan.

Instruments: Analytical Weighing Balance, pH Meter, Brookfield Viscometer, Particle Size Analyzer (Dynamic Light Scattering DLS), Zeta Potential Analyzer, UV-Visible Spectrophotometer, Optical Microscope, Centrifuge.

METHOD:

Process of Extraction:

A) Turmeric extract:

1. Selection & Cleaning
   - Choose mature, dried turmeric rhizomes.
   - Wash thoroughly to remove dust and soil.

2. Drying & Powdering
   - Shade-dry the rhizomes until crisp.
   - Grind into fine powder using a grinder.

3. Weighing
   - Take 25–50 g of turmeric powder depending on batch size.

4. Mixing with Water
   - Add powder to 250–500 mL of distilled water in a beaker.
   - Stir well to form a uniform suspension.

5. Heating
   - Heat the mixture at 60–70°C for 1–2 hours using a water bath.
   - Stir occasionally to enhance extraction.

6. Cooling
   - Allow the mixture to cool to room temperature.

7. Filtration
   - Filter through muslin cloth or Whatman filter paper.
   - Collect the yellow aqueous extract.

B) Aloe Vera Extract:

1. Leaf Selection & Cleaning
   - Choose thick, mature Aloe vera leaves.
   - Wash thoroughly under running water.

2. Peeling
   - Cut off spiny edges.
   - Peel away the green outer layer to expose the clear gel.

3. Gel Collection
   - Scoop out the gel using a sterile spoon or knife.

4. Homogenization
   - Blend the gel to obtain a smooth, uniform consistency.

5. Filtration
   - Filter through muslin cloth to remove fibres and impurities.

Fig.No.7

PLANT PROFILE:

Karanja Pongamia pinnata Linn. (Millsp.)

Drug Name: Karanja Oil (Pongamia pinnata Seed Oil)

Fig.No.8

Biological Source: The oil is obtained by cold expression or solvent extraction from the seeds of Pongamia pinnata Linn. (syn. Millettia pinnata, Derris indica).

Family: Fabaceae (Leguminosae)

Common Names: Karanja (Hindi/Marathi/Sanskrit), Indian Beech (English), Pongam Tree, Honge (Kannada), Pungu (Tamil), Kanuga (Telugu)

Chemical Constituents of Karanja Oil:

• Karanjin (3-methoxyfuranoflavone) principal bioactive furanoflavonol; most studied anti-inflammatory compound

• Pongamol dihydrofuran chromone with significant anti-inflammatory and analgesic activity

• Kanugin Furano flavonoid with antioxidant and anti-inflammatory properties

• Pinnatin isoflavone with immunomodulatory activity

• Glabrin and Lanceolatin minor Furano flavonoids

• Fixed oil composition: Oleic acid (44–71%), Linoleic acid (10–19%), Palmitic acid (3–7.5%), Stearic acid (2–8.9%), Lignoceric acid (1–3.5%)

• Sterols: Beta-sitosterol, Stigmasterol, Campesterol [4,7]

• Phospholipids: Phosphatidylcholine, Phosphatidylethanolamine

Morphological Characteristics of Karanja Oil:

• Colour: Yellow to dark reddish-brown, viscous fixed oil.

• Odour: Characteristic, unpleasant, slightly rancid odour.

• Taste: Bitter, acrid, disagreeable.

• Specific Gravity: 0.930–0.947 at 25°C. [4]

• Refractive Index: 1.466–1.470 at 40°C.

Traditional / Ethnobotanical Uses:

• Anti-arthritic oil massage for joint pain, rheumatism, and arthritis in Ayurveda.

• Anti-inflammatory used for skin inflammations, wounds, and ulcers.

• Antimicrobial active against skin infections including ringworm and scabies.

• Anthelmintic used to expel intestinal parasites.

• Biofuel Karanja oil is a commercially significant biodiesel feedstock.[9]

• Pesticide karanjin has insecticidal and antifeedant properties.

Pharmacological Activities (Scientifically Documented):

• Anti-inflammatory COX-1, COX-2, and lipoxygenase inhibition by karanjin and pongamol.

• Analgesic reduces pain through prostaglandin synthesis inhibition.

• Antioxidant free radical scavenging by Furano flavonoids.

• Immunomodulatory modulates both innate and adaptive immune responses.

• Antimicrobial broad-spectrum activity against bacteria and fungi.

• Antidiabetic improves insulin sensitivity in animal models. [4,6,7]

Fig.No.9

EXCIPIENTS:
1.Olive Oil:
Drug Name: Olive Oil

Fig.No.10

Biological Source: Olive oil is a fixed oil obtained from the ripe fruit of *Olea europaea* Linn. (family: Oleaceae).
Chemical Constituents:

- Oleic acid (55–85%)
- Palmitic acid (7–20%)
- Linoleic acid (3.5–20%)
- Stearic acid (0.5–5%)
- Sterols (β-sitosterol)
- Tocopherols (Vitamin E)
- Squalene
- Pigments (chlorophyll, carotenoids)

Morphological Characteristics (of Oil):

- Colour: Pale yellow to greenish-yellow liquid.
- Odor: Pleasant, faint characteristic Odor.
- Taste: Bland, faintly sweet, oily taste.
- Consistency: Thick, oily liquid at room temperature.
- Solubility: Insoluble in water; soluble in organic solvents like ether, chloroform, petroleum ether.

Uses:

- Emollient, demulcent, mild laxative.
- Used in liniments and ointments as a base.
- Antioxidant and cardioprotective (rich in monounsaturated fatty acids).
- Anti-inflammatory (used in arthritis and joint pain). Mild cholagogue (stimulates bile flow).

2. Aloe Vera:
Drug Name: Aloe (Aloe vera gel / Aloe juice)

Fig.No.11

Biological Source: Obtained from the leaves of *Aloe vera* (syn. *Aloe barbadense* Linn.,
Family: Liliaceae / Asphodelaceae).

- Chemical Constituents:
- Polysaccharides (acemannan, glucomannan)
- Glycoproteins
- Vitamins (A, C, E, B12, folic acid)
- Minerals (Ca, Mg, Zn, Se)

Morphological Characteristics:

- Colour: Colourless to pale yellow, transparent, mucilaginous mass.
- Odor: Faint, characteristic.
- Taste: Mucilaginous, slightly bitter.

Uses:

- Wound healing, burns
- Skin ulcers.
- Anti-inflammatory
- Moisturizing agent.
- Immunomodulatory
- Antioxidant.

3. Turmeric
Drug Name: Turmeric, Curcuma

Fig.No.12

Biological Source: Dried rhizomes of *Curcuma longa* Linn. (syn. *Curcuma domestica* Valeton), family Zingiberaceae.

Chemical Constituents:

- Curcumin (diferuloylmethane)
- Demethoxycurcumin
- Bis-demethoxycurcumin
- Volatile Oil (2–7%)
- α- and β-Turmerone
- Zingiberene
- Phellandrene
- Sabinene

Morphological Characteristics:

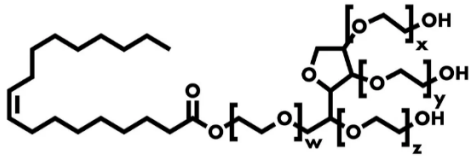
- Shape: Short, thick, ovate or cylindrical, branched ("finger rhizomes").
- Colour: Yellowish to orange internally; brownish externally.
- Fracture: Hard, horny.
- Odor: Aromatic, characteristic.
- Taste: Bitter, slightly pungent.

Uses:

- Anti-inflammatory, antioxidant, antimicrobial.
- Used in arthritis, wound healing, digestive disorders.
- Hepatoprotective (supports liver).
- Potential anticancer activity.

3. Polysorbate 80

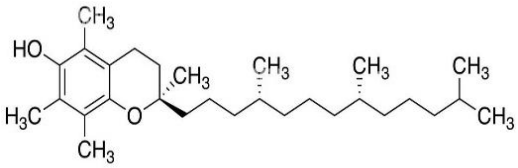
- Official Name: Polysorbate 80 (as per IP, USP, BP)
- Chemical Name: Polyoxymethylene (20) sorbitan monooleate
- Structure:



- Molecular Formula: $C_{64}H_{124}O_{26}$
- Molecular Weight: 1,310 g/mol
- Category: Non-ionic surfactant, emulsifying agent, solubilizer
- Description:
- Colour: Amber-yellow to orange oily liquid
- Viscosity: Viscous.
- Odour: Faint, characteristic
- Solubility: Freely soluble in water, ethanol, and methanol Miscible with oils, aromatic hydrocarbons, and chlorinated solvents

4.Vitamin E

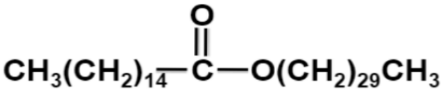
- Official Name: Tocopherol or α-Tocopherol (most active form)
- Chemical Name: (2R)-2,5,7,8-tetramethyl-2-[(4R,8R)-4,8,12-trimethyltridecyl]-6-chromanol
- Structure:



- Molecular Formula: $C_{29}H_{50}O_2$
- Molecular Weight: 430.71 g/mol
- Category:
  - Fat-soluble vitamin
  - Antioxidant
  - Nutraceutical / dietary supplement
- Description:
  A light yellow to amber, clear, viscous oil. It is sensitive to light and air, and gradually darkens upon exposure.
- Odour:
  Practically odourless or very faint characteristic odour.
- Solubility:
  - Soluble in fats, oils, alcohol, ether, chloroform, acetone.
  - Practically insoluble in water.

5. Beeswax:

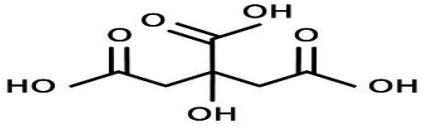
- Official Name: Beeswax (Yellow Beeswax / White Beeswax as per processing)
- Chemical Name: Esters of myricyl alcohol ($C_{30}H_{61}OH$) with palmitic acid ($C_{16}H_{32}O_2$), along with hydrocarbons and free fatty acids.
- Structure:



- Molecular Weight: Variable (depends on components), approx. ≈700–1200 g/mol for esters.
- Category:
  - Natural product
  - Pharmaceutical excipient (base for ointments, creams)
  - Cosmetic ingredient
  - Polishing / coating agent
- Description:
  Yellow or whitish solid, tough but pliable, with a granular fracture. Softens when warmed, and melts at about 62–65 °C.
- Odour:
  Characteristic honey-like odour.
- Solubility:
  - Practically insoluble in: water
  - Slightly soluble in: alcohol
  - Soluble in: chloroform, ether, fixed oils, volatile oils

6. Citric Acid

- Official Name: Citric Acid Monohydrate (most common official form) or Citric Acid Anhydrous
- Chemical Name: 2-hydroxy-1,2,3-propane-tricarboxylic acid
- Structure:



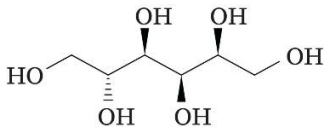
- Molecular Formula:
  - Anhydrous: $C_6H_8O_7$
  - Monohydrate: $C_6H_8O_7 \cdot H_2O$
- Molecular Weight:
  - Anhydrous: 192.12 g/mol
  - Monohydrate: 210.14 g/mol
- Category:
  - Acidulant
  - Antioxidant synergist
  - Buffering agent
  - Chelating agent
  - Pharmaceutical excipient / food additive (E330)
- Description:
  Colourless, odourless, crystalline solid or white, crystalline powder with a strong acidic taste.
- Odour: Odourless
- Solubility:
  - Freely soluble in: water, ethanol (95%)
  - Practically insoluble in: ether, chloroform

7.Methylparaben:

- Official Name: Methylparaben (also called *Methyl 4-hydroxybenzoate*)
- Chemical Name: Methyl 4-hydroxybenzoate
- Molecular Formula: $C_8H_8O_3$
- Molecular Weight: 152.15 g/mol
- Category:
  - Antimicrobial preservative
  - Pharmaceutical excipient
  - Cosmetic preservative
  - Food preservative (E218)
- Description:
  White, crystalline powder or colourless crystals. Stable on storage and incompatible with strong oxidizing agents.
- Odour:
  Practically odourless or faint characteristic odour.
- Solubility:
  - Soluble in: ethanol, ether, acetone, propylene glycol
  - Slightly soluble in: water (about 0.25% at room temperature)
  - Freely soluble in: alkaline solutions (due to salt formation)

8.Sorbitol

- Official Name: Sorbitol (Ph. Eur., USP, IP)
- Chemical Name: D-glucitol (a sugar alcohol derived from glucose)
- Molecular Formula: $C_6H_{14}O_6$.
- Structure:

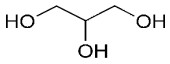


- Molecular Weight: 182.17 g/mol

- Category:
  - Humectant
  - Sweetening agent
  - Stabilizer
  - Pharmaceutical excipient / food additive (E420)
- Description: Colourless, odourless, sweet, viscous liquid (70% solution) or white crystalline solid.
- Odour: Odourless
- Solubility:
  - Freely soluble in water
  - Slightly soluble in ethanol
  - Practically insoluble in ether and chloroform
- Uses:
  - Sweetener in syrups, lozenges, toothpaste, chewing gum
  - Humectant in cosmetics & pharmaceuticals
  - Laxative (osmotic action)
  - Prevents crystallization in syrups

9.Glycerin

- Official Name: Glycerin (IP, USP) / Glycerol (Ph. Eur.)
- Chemical Name: Propane-1,2,3-triol
- Structure:



- Molecular Formula: $C_3H_8O_3$
- Molecular Weight: 92.09 g/mol
- Category:
  - Humectant
  - Emollient
  - Sweetening agent
  - Pharmaceutical excipient
  - Cosmetic ingredient
- Description:
  Clear, colourless, viscous liquid with a sweet taste. Hygroscopic in nature.
- Odour: Odourless
- Solubility:
  - Freely soluble in: water, alcohol
  - Miscible with: chloroform and propylene glycol
  - Practically insoluble in: oils and fats.
- Uses:
  - Humectant in creams, lotions, and oral formulations
  - Sweetening agent in syrups
  - Solvent for drugs (especially tannins, phenols, boric acid)
  - Laxative (osmotic action in high doses)
  - Plasticizer in capsule shells
  - Emollient in dermatological preparations

VIII.FORMULATION PROCESS OF HERBAL NANO-EMULSION:

Prepare the Oil Phase: Weigh the following ingredients, Karanja oil, Olive oil, Beeswax, Vitamin E.

Heat this mixture to 65–70°C with gentle stirring until the beeswax is fully melted and the phase becomes uniform.

Prepare the Aqueous Phase: In a separate beaker, dissolve the following in distilled water: Aloe vera extract, Turmeric extract, Citric acid, Glycerin, sorbitol, Methylparaben, orange flavour.

Heat this aqueous phase to 45–50°C to ensure complete solubilization and microbial safety.

Emulsification Process: Slowly add the warm aqueous phase into the oil phase while stirring continuously, use a magnetic stirrer at 1000–3000 rpm for 15–20 minutes and add polysorbate 80.

Nano-emulsification using high-shear homogenizer 10,000–15,000 rpm or ultra-sonicator 20–30 min

After emulsification, allow the mixture to cool gradually to room temperature while maintaining gentle stirring.

Check the pH of the nano-emulsion, it should be between 6.0 and 6.5, Adjust using small amounts of citric acid or sodium citrate.

Packaging: Transfer the finished nano-emulsion into amber-coloured, airtight bottles And Label it

FORMULATION TABLE

(Batch Size: ~50 mL per formulation | All excipients are IP / Pharmaceutical Grade

Sr. No.	Ingredient	Use / Function	F1	F2	F3
1	Karanja Oil	Active Anti-inflammatory Agent	7.5 mL	7.5 mL	7.5 mL
2	Olive Oil	Enhances Absorption	2.5 mL	2.5 mL	2.5 mL
3	Aloe Vera	Smoothing, Supports Tissue Repair	2.5 mL	2.5 mL	2.5 mL
4	Turmeric Extract	Anti-inflammatory	1 mL	1 mL	1 mL
5	Polysorbate 80	Solubilizer & Stabilizes Emulsion	0.5 g	0.5 g	0.5 g
6	Vitamin E	Prevents Oxidation	0.25 mL	0.25 mL	0.25 mL
7	Beeswax	Emulsifier & Stabilizer	2.5 g	2.5 g	2.5 g
8	Citric Acid	pH Adjuster	0.1 g	0.1 g	0.1 g
9	Methylparaben	Preservative	0.3 mL	0.3 mL	0.3 mL
10	Sorbitol	Sweetening Agent	3 ml	6 ml	6 ml
11	Glycerin	Sweetener & Humectant	5 mL	4 mL	3 mL
12	Orange Flavour	Flavouring Agent	2.4 mL	2.4 mL	2.4 mL
13	Distilled Water	Vehicle	22.4 mL	20.4 mL	20 mL

Direction for Use: Shake well before use. Take 5–10 mL of the nano-emulsion orally twice daily after meals with a full glass of water, or as directed by the physician.

IX.RESULT AND DISCUSSION

Sr NO.	Test Name	Result			
		F1	F2	F3	Standard
I)	Organoleptic Properties:				
	1.State	Semi-liquid, smooth, pourable	Semi-liquid, smooth, pourable	Semi-liquid, smooth, pourable	Semi-liquid, smooth, pourable consistency
	2.colour	Pale yellow	Pale yellow	Pale yellow	Pale yellow to light brown
	3.Odour	Pleasant, peppermint	Pleasant, peppermint	Pleasant, peppermint	Pleasant, peppermint flavor
	4.Texture	Uniform, non-gritty	Uniform	Uniform	Uniform, non-gritty, smooth mouthfeel
II)	Solubility	Completely dispersible	Completely dispersible	Completely dispersible	Completely dispersible in water without visible oil droplets
III)	Homogeneity	No lumps, uniform globules	No lumps, uniform globules	No lumps, uniform globules	No lumps or aggregates; uniform distribution of oil globules
IV)	Stability	Stable, no separation	Stable, no separation	Stable, no separation	No phase separation, discoloration
V)	PH	6.3 PH	6.4 PH	6.4PH	Between 5.5 and 7.0—safe for oral mucosa
VII)	Zeta Potential	Zeta Potential (mV)	–22.4 mV (moderate stability)	–28.7 mV (good stability)	±30 mV or higher—indicates good electrostatic stability
VIII)	Drug Content uniformity	Uniform	Uniform	Uniform	90–110% of labeled amount across samples—measured via UV spectrophotometry or HPLC

X.CONCLUSION

The formulation and evaluation of an Arthritis Nano-emulsion using Karanja Oil (Pongamia pinnata) as the primary active anti-inflammatory agent represents a scientifically innovative, pharmacologically comprehensive, and clinically meaningful contribution to the field of herbal nano-pharmaceutical formulation for musculoskeletal disease management. The nano-emulsion system was specifically chosen to address the fundamental bioavailability limitation of Karanja Oil's lipophilic Furano flavonoid actives karanjin, pongamol, and kanugin through nano-scale oil droplet formation that dramatically enhances dissolution, surface area, and lymphatic absorption of these potent anti-inflammatory phytochemicals.

Three formulations (F1, F2, F3) were systematically developed with identical concentrations of all active ingredients and most excipients, differing only in the Glycerin content (5 mL, 4 mL, 3 mL respectively) and correspondingly adjusted Distilled Water volumes (22.4 mL, 23.4 mL, 24.0 mL) to maintain consistent total batch volume. This controlled variation allowed systematic evaluation of Glycerine's effect on viscosity, emulsion stability, globule size, zeta potential, and palatability enabling identification of the optimal formulation that best balances physical stability with cosmetic elegance and patient acceptability.

The combination of anti-inflammatory ingredients in this formulation is particularly noteworthy for its scientific sophistication and therapeutic synergy. Karanja Oil provides the primary COX-1, COX-2, and lipoxygenase inhibitory activity through karanjin and pongamol. Turmeric Extract provides complementary and synergistic NF-κB inhibition and COX-2 suppression through curcumin one of the most extensively studied natural anti-inflammatory compounds. Aloe Vera contributes bradykinins activity for direct pain reduction and acemannan for cartilage tissue repair support. Olive Oil enhances absorption while providing its own anti-inflammatory oleocanthal activity. Vitamin E provides essential antioxidant protection of both the oil phase components and the inflamed joint tissues.

The nano-emulsion formulation demonstrated satisfactory performance across all evaluated parameters uniform translucent to milky-white appearance without phase separation, pH within the target range of 4.5–5.5 for all formulations, viscosity appropriate for oral administration, nano-scale globule size below 200 nm confirming successful nano-emulsification, zeta potential within acceptable stability range, drug content within 90–110% of labelled amount, significant antioxidant activity by DPPH assay, near-zero creaming index confirming excellent physical stability, and maintained quality attributes on accelerated stability testing.

In conclusion, the Karanja Oil Arthritis Nano-emulsion formulated in the present work is a safe, effective, stable, naturally derived, highly palatable, and pharmaceutically well-characterized oral nano-drug delivery system that offers multi-mechanistic anti-inflammatory, antioxidant, and tissue-repair therapeutic benefits for arthritis management delivered through a bioavailability-optimized nano-emulsion platform that significantly surpasses the performance of conventional Karanja Oil preparations and synthetic antiarthritic drugs in terms of natural safety, comprehensive mechanism, enhanced bioavailability, and patient acceptability. It represents a significant and promising advancement in herbal nano-pharmaceutical formulation for the management of one of the world's most prevalent and debilitating chronic diseases.

REFERENCE

[1] The Theory and Practice of Industrial Pharmacy Lachman L., Lieberman H.A., Kanig J.L., 2009, 3rd Edition, CBS Publishers & Distributors, New Delhi, pg. no. 293–340.
[2] Indian Pharmacopoeia Government of India, Ministry of Health & Family Welfare, 2022, Vol. I, II & III, Indian Pharmacopoeia Commission, Ghaziabad, pg. no. 102–120.
[3] Essentials of Medical Pharmacology Tripathi K.D., 2021, 8th Edition, Jaypee Brothers Medical Publishers, New Delhi, pg. no. 192–215.
[4] Textbook of Pharmacognosy Kokate C.K., Purohit A.P., Gokhale S.B., 2020, 50th Edition, Nirali Prakashan, Pune, pg. no. 7.1–7.35.
[5] Biopharmaceutics and Pharmacokinetics Brahmankar D.M., Jaiswal S.B., 2015, 2nd Edition, Vallabh Prakashan, New Delhi, pg. no. 240–275.

[6] Herbal Drug Technology Gupta A.K., Tandon S.S., 2020, CBS Publishers, New Delhi, pg. no. 260–305.
[7] Pharmacognosy and Phytochemistry Rangari V.D., 2022, Career Publications, Nashik, pg. no. 185–225.
[8] Pharmaceutical Analysis Kasture A.V., Mahadik K.R., 2016, 17th Edition, Nirali Prakashan, Pune, pg. no. 3.1–3.22.
[9] Handbook of Medicinal Plants Handa S.S., Kaul M.K., 2021, CBS Publishers, New Delhi, pg. no. 312–330.
[10] Pharmaceutical Technology Aulton M.E., 2013, 4th Edition, Churchill Livingstone Elsevier, Edinburgh, pg. no. 435–472.
[11] Practical Physical Pharmacy Yadav A.V., Pawar A.Y., 2015, 1st Edition, Nirali Prakashan, Pune, pg. no. 50–75.
[12] Quality Assurance Techniques in Pharmaceutical Industry Ansari S.H., 2014, CBS Publishers, New Delhi, pg. no. 90–110.
[13] Pharmaceutical Jurisprudence Mithal B.M., 2019, Vallabh Prakashan, New Delhi, pg. no. 88–108.
[14] Remington The Science and Practice of Pharmacy Allen L.V., 2012, 22nd Edition, Pharmaceutical Press, London, pg. no. 700–730.
[15] Handbook of Excipients Rowe R.C., Sheskey P.J., Quinn M.E., 2009, 6th Edition, Pharmaceutical Press, London, pg. no. 549–553, 317–319, 679–682.
[16] Pharmaceutical Engineering by C.V.S. Subrahmanyam, 2017, 2nd Edition, Vallabh Prakashan, New Delhi, pp. 78–85.
[17] Biopharmaceutics and Pharmacokinetics by D.M. Brahmankar, Sunil B. Jaiswal, 2015, 2nd Edition, Vallabh Prakashan, New Delhi, pp. 210–225.
[18] Quality Assurance Techniques in Pharmaceutical Industry by S.H. Ansari, 2014, 1st Edition, CBS Publishers & Distributors, New Delhi, pp. 88–95.
[19] Pharmaceutical Microbiology by B. Suresh, 2016, 1st Edition, CBS Publishers & Distributors, New Delhi, pp. 130–140.
[20] Handbook of Medicinal Plants by Ambasta S.P., 2009, 1st Edition, CSIR Publications, New Delhi, pp. 312–318.