

**FORMULATION AND EVALUATION OF BETEL LEAVES (*PIPER BETLE*) INFUSED OIL FOR JOINT PAIN RELIEF****Krupa Waravdekar¹, Sachin Sonavane^{*2}**

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ABSTRACT

Joint pain is a chronic condition affecting individuals of diverse age groups, commonly arising due to inflammation, arthritis, or age-related degeneration. The present study focuses on developing and evaluating a natural joint pain relief formulation using betel leaves (*Piper betle*), known for their anti-inflammatory, analgesic, and antioxidant properties. Fresh betel leaves were infused into cold-pressed coconut oil through a controlled heat extraction method to obtain a phytochemical-rich preparation. The formulated oil was assessed for physicochemical properties, including color, aroma, texture, absorption, pH, and stability. Additionally, patch testing and a user survey were conducted to evaluate safety and acceptability. Results indicated a stable formulation with favorable sensory attributes, rapid absorption, and high user tolerance, with 90.9% of participants showing no adverse skin

reactions. The findings suggest that *Piper betle*-infused oil has significant potential as a natural alternative for managing joint pain. Further clinical validation and optimization studies are recommended to standardize the product for therapeutic and commercial applications.

KEYWORDS: *Piper betle*; joint pain relief; infused oil; herbal formulation; anti-inflammatory; analgesic; natural therapy; anti-inflammatory; anti-oxidants.

1. INTRODUCTION

Betel (*Piper betle*) Figure-1 is a species of flowering plant in the pepper family Piperaceae. Binomial name of Betel is *Piper betle* L. The importance of using medicinal plants as therapeutics has increased recently because they have less contrary effects than manufactured. Joint pain is a prevalent musculoskeletal condition that hinders mobility and significantly affects quality of life. Existing pharmacological treatments, including non-steroidal anti-inflammatory drugs (NSAIDs) and synthetic analgesics, provide symptom relief but are associated with adverse effects during prolonged use. Betel leaves contain anti-inflammatory properties that can help reduce joint pain and discomfort, which is a common symptom of many chronic diseases, including rheumatoid arthritis and osteoporosis^[1,2] Consequently, there is increasing interest in safe, natural, and plant-based alternatives for long-term joint pain management.

Piper betle (betel leaf) is traditionally used in Ayurvedic, Chinese, and Southeast Asian medicinal systems. It contains a broad range of bioactive compounds such as eugenol, hydroxychavicol, phenolics, tannins, and flavonoids, which exhibit potent anti-inflammatory, analgesic, antimicrobial, and antioxidant activities.^[3,4,5] Its essential oil consists of 50 different compounds of which major components eugenol, caryophyllene, terpinolene, terpinene, cadinene, and 3-carene.^[3] Previous research confirms its ability to inhibit inflammatory mediators and reduce oxidative stress.



Figure : 1.

Betel leaf (*Piper betle*)

Chavibetol^[3,5] Figure- 2 is an organic chemical compound of the phenylpropanoid class. It is one of the primary constituents of the essential oil from leaves of the betel plant. It is an aromatic compound with a spicy odor.

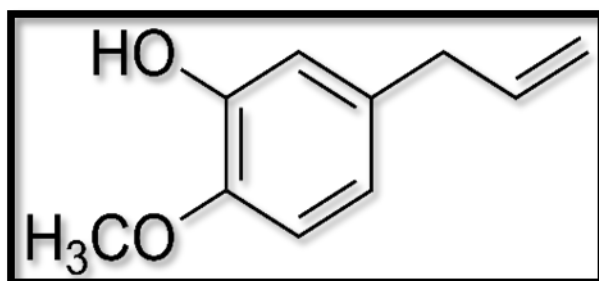


Figure: 2.

Chavibetol

The main active compound in betel leaf responsible for its anti-inflammatory properties are phenolic compounds, flavonoids and terpenoids.^[3]

Given its therapeutic potential, the present study aims to formulate and evaluate a betel leaf-infused topical oil designed for joint pain relief. The study includes physicochemical assessment, stability analysis, and user safety evaluation to determine its suitability as a natural therapeutic agent.

Camphor (*Cinnamomum camphora*) produces a warming sensation, which improves local blood circulation, Functions as a counter-irritant, distracting pain receptors and providing quick relief.^[6]

Lemongrass (*Cymbopogon citratus*) Leaves are rich in citral and flavonoids, which show anti-inflammatory and antioxidant activity, Helps in reducing joint inflammation and muscle spasms.^[7]

Rosemary Essential Oil (*Rosmarinus officinalis*) contains rosmarinic acid and carnosic acid, strong antioxidants, Helps relieve rheumatic pain, stiffness, and muscular discomfort. Contributes to formulation stability by preventing oxidative degradation of oils.^[8]

2. MATERIALS AND METHODS

2.1 Materials

- Fresh *Piper betle* leaves (20 g)
- Lemon Grass leaves (*Cymbopogon citratus*) (10 g)
- Cold-pressed coconut oil (100 mL)
- Camphor(*Cinnamomum camphora*) (2 g)
- Rosemary essential oil (*Rosmarinus officinalis*) (few drops)
- Glass jar, stainless-steel pot, muslin cloth
- pH meter, heating plate, amber storage bottle.

2.2 Preparation of Betel Leaf-Infused Oil

Fresh betel leaves were washed, shade-dried for 48 h, and chopped (Figure- 3). Dried, Chopped Betel leaves and lemon grass leaves were extracted into coconut oil using Soxhlet extraction to obtain an oil rich in phytochemicals. After extraction, the oil was heated at 40–50 °C for 4–6 hours with occasional stirring to ensure uniform infusion. After cooling, camphor and a few drops of rosemary essential oil were added to the extract below 40°C, followed by filtration through muslin cloth, and the final product was stored in amber glass bottles to prevent photodegradation (Figure-4).



Figure: 3.

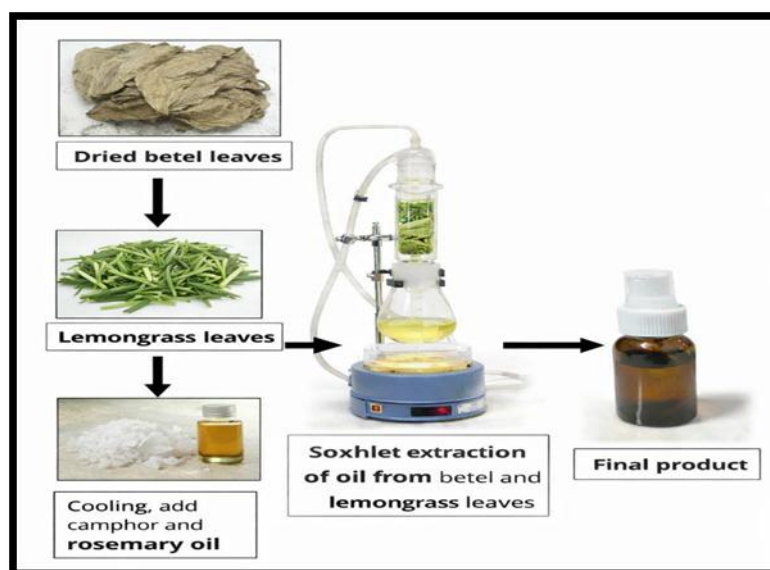


Figure: 4.

2.3 Evaluation Parameters

The formulation was evaluated for

- **Organoleptic properties:** color, aroma, texture
- **pH measurement:** skin friendly according to skin mantle (4.5 - 5.5)
- **Spreadability and absorption:** Rapid absorption, no phase separation
- **Stability tests:** observation under varying temperatures for 4 weeks
- **Patch test:** conducted on volunteers to assess irritation potential (Figure-5,6 &7)
- **User survey:** to determine acceptability and comfort.

3. RESULTS

3.1 Organoleptic Properties

The infused oil exhibited a light-to-deep green color with a mild, peppery aroma characteristic of betel leaves. The texture was smooth, light, and non-greasy.

3.2 Absorption and Stability

The oil demonstrated rapid absorption with no greasy residue. Stability analysis for 4 weeks showed no phase separation, discoloration, or rancidity.

Patch Test

- 90.9% = no reaction
- 9.1% = mild itchiness

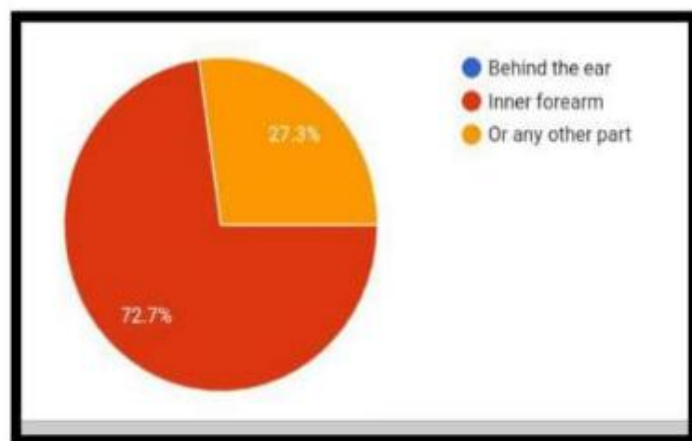


Figure: 5 Application site: 72.7% on inner forearm.

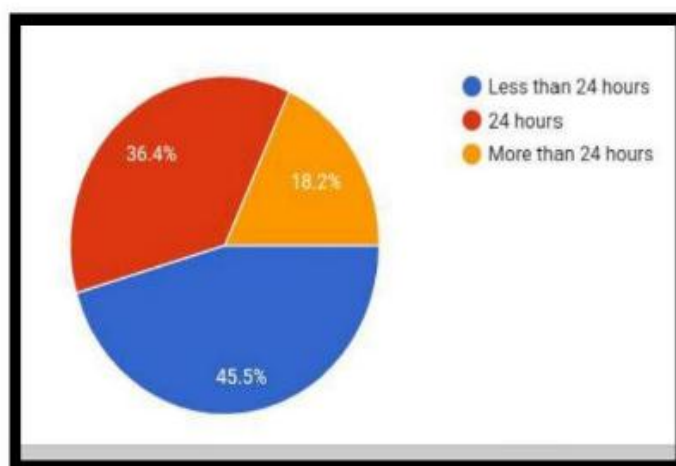


Figure -6:- Application duration: Majority (<24 h).

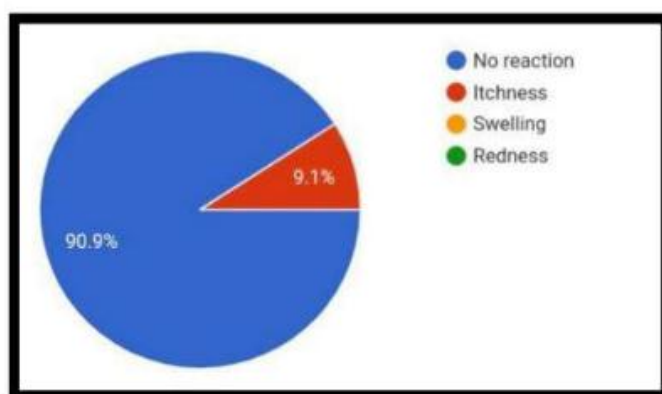


Figure -7:- Skin reaction: Results after 12 hours from application of oil.

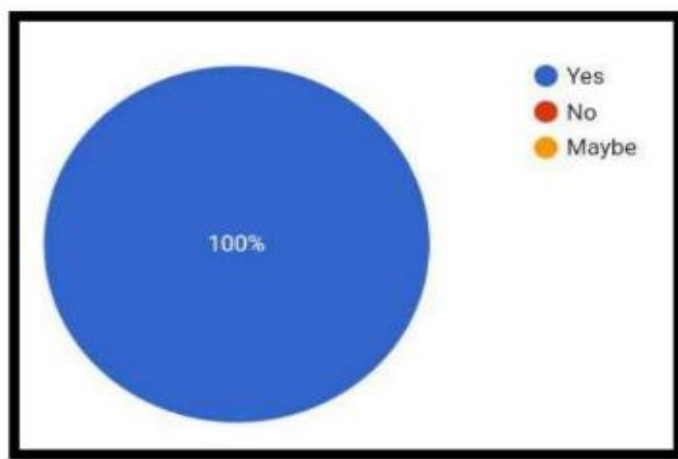


Figure - 8:- Comfort level: 100% reported comfort.

The results indicate excellent skin compatibility and minimal sensitization.

4. DISCUSSION

The physicochemical evaluation confirmed successful extraction of *Piper betle* phytochemicals into coconut oil. The green coloration and aromatic profile indicate efficient infusion of active compounds such as eugenol and phenolics, known for their anti-inflammatory and analgesic properties.

Camphor was incorporated to provide immediate analgesic and counter-irritant effects, helping to relieve joint pain and stiffness.^[6] Lemongrass leaves contributed anti-inflammatory and antioxidant properties, supporting reduction of inflammation associated with joint discomfort.^[7] Rosemary essential oil enhanced the overall analgesic activity and improved peripheral blood circulation at the site of application.^[8] The essential oil also acted as a penetration enhancer, facilitating better absorption of betel leaf phytoconstituents. Antioxidant components from lemongrass and rosemary improved the oxidative stability of the infused oil. Collectively, these ingredients synergistically enhanced the therapeutic efficacy of betel leaf infused oil for joint pain relief.^[6-8]

Antioxidants in betel leaves work by neutralizing free radicals, which are unstable molecules that cause cellular damage. The leaves are rich in bioactive compounds like phenols, flavonoids, and eugenol that prevent oxidative stress and reduce inflammation.^[9] Studies have shown that compounds in betel leaves can reduce inflammation by downregulating inflammatory pathways like the NF- κ B and MAPK pathways.^[10] Betel leaf extract containing polyphenols compounds like catechol, allyl pyrocatechol responsible

for antioxidant activity.^[11] Antioxidant properties help to combat inflammation, which is a key factor in many chronic diseases.^[12,13]

The high user acceptance, coupled with low incidence of irritation, confirms the formulation's suitability for topical application. Compared to synthetic analgesics, herbal oils offer reduced side effects and better long-term applicability. However, the lack of extended stability and clinical trials limits current therapeutic claims.

Commercially, the product aligns with increasing consumer preference for herbal pain-relief formulations. Optimization of extraction parameters and standardization is necessary for large-scale manufacturing.

5. CONCLUSION

The study conclusively demonstrates that *Piper betle* - infused oil is a promising natural alternative for managing joint pain. It exhibits desirable sensory characteristics, high stability, and excellent skin tolerability. The presence of potent phytochemicals supports its anti-inflammatory and analgesic potential.

The natural infusion process, using cold or slow heat methods, successfully extracts bioactive compounds without the use of synthetic chemicals, ensuring a safe and effective formulation. The absence of chemical additives makes it a promising alternative for individuals seeking natural pain relief options.

Future research can focus on enhancing its stability, exploring complementary herbal combinations, and evaluating its market potential as a commercial product.

Future research should focus on

- Large-scale clinical trials
- Quantitative phytochemical profiling
- Long-term stability studies
- Development of advanced topical forms such as gels, creams, or sprays.

This formulation can contribute to expanding herbal therapeutics in joint pain management.

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