Nyctanthes arbor tristis Fruit Emulgel: Formulation, Evaluation, and Potential for Osteoarthritis Management

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Abstract: Osteoarthritis is a common and debilitating degenerative joint disorder affecting millions of individuals worldwide. Managing osteoarthritis remains a challenge, necessitating the exploration of novel and effective therapeutic approaches. In recent years, natural products derived from medicinal plants have gained significant attention for their potential as alternative treatments due to their anti-inflammatory and analgesic properties. The Emulgel formulations are prepared with Carbopol 940, Carbopol 934, and Hydroxypropyl Methylcellulose (HPMC) as gelling agents to impart stability and controlled drug release characteristics. The physicochemical evaluations ensure the Emulgels possess optimal properties, including appropriate pH, suitable viscosity, and spreadability. These properties are essential for enhancing skin compatibility, easy application, and uniform coverage of the affected area. In vitro drug release studies provide insights into the drug release behavior of the formulations. The results demonstrate sustained drug release patterns over an 8-hour period, indicating controlled and extended drug delivery. This sustained release has the potential to provide prolonged therapeutic effects, reducing the frequency of application and enhancing patient compliance. The promising results obtained from this study indicate that the formulated Emulgels containing *Nyctanthes arbor tristis* fruit extract hold great potential as topical treatments for osteoarthritis.

Keywords: Osteoarthritis, *Nyctanthes arbor tristis*, Emulgel, Phytochemical analysis, Viscosity, Spreadability, In vitro drug release

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Introduction

Osteoarthritis (OA) is a debilitating joint disorder characterized by the progressive degradation of articular cartilage, subchondral bone remodeling, and chronic inflammation within the synovial membrane [1]. As one of the most prevalent musculoskeletal conditions globally, OA poses a significant burden on healthcare systems and adversely impacts the quality of life of affected individuals [2]. Conventional treatments, including nonsteroidal anti-inflammatory drugs (NSAIDs) and analgesics, provide limited symptomatic relief and often come with unwanted side effects. As a result, there is an increasing interest in exploring natural remedies with potential therapeutic benefits for OA management [3].

Among the various medicinal plants utilized in traditional medicine systems, *Nyctanthes arbor tristis* (NAT), commonly known as the "Night-flowering Jasmine" or "Parijat," has emerged as a promising candidate due to its rich phytochemical composition and historical use in treating inflammatory disorders, including arthritis [4]. NAT is a deciduous shrub native to the Indian subcontinent, Southeast Asia, and parts of Australia. In traditional Ayurvedic medicine, the leaves, flowers, and fruits of NAT have been employed to address various ailments, such as arthritis, rheumatism, and other inflammatory conditions [5].

Phytochemical investigations of NAT have revealed the presence of diverse bioactive compounds, including flavonoids, alkaloids, glycosides, terpenoids, and phenolic compounds [4]. These phytoconstituents possess potent anti-inflammatory, analgesic, and antioxidant properties, making NAT a compelling candidate for potential use in OA management. Among the different parts of the plant, the fruits of NAT have been comparatively less studied, particularly concerning their application in topical formulations [6].

Emulgel, a unique combination of emulsion and gel, has garnered considerable interest in pharmaceutical research due to its ability to deliver both hydrophobic and hydrophilic drugs through a dual-release mechanism [7]. The Emulgel formulation provides advantages such as improved drug penetration, prolonged drug release, and enhanced patient compliance. However, the application of NAT fruit extract in an Emulgel for OA management remains relatively unexplored [8].

The primary objective of this research is to formulate and evaluate a novel *Nyctanthes arbor tristis* fruit Emulgel for potential use in the management of osteoarthritis. This study

aims to investigate the phytochemical composition of the NAT fruit extract, optimize the Emulgel formulation, and assess its physical properties, stability, in vitro drug release profile, and anti-inflammatory and analgesic efficacy using relevant experimental models [9].

The significance of this research lies in its potential to introduce a natural-based, alternative therapy for OA, harnessing the therapeutic potential of NAT fruit extract. If successful, this novel emulgel may offer an innovative approach to alleviating OA symptoms while minimizing the adverse effects associated with conventional treatments [10]. Additionally, the study may contribute to the growing body of research on phytopharmaceuticals, fostering interest in exploring the rich biodiversity of medicinal plants for the development of effective and safe therapeutic interventions for osteoarthritis and other inflammatory disorders [11].

Materials and Methods

Collection of Plants [12]

Nyctanthes arbor tristis fruits were collected from a well-established botanical garden in Delhi. The plant material was identified and authenticated by a qualified botanist. The fruits were washed, air-dried, and stored in an airtight container until further use.

Phytochemical Analysis [13]

Phytochemical analysis of the *Nyctanthes arbor tristis* fruit extract was carried out to identify and quantify various phytoconstituents. The dried fruit material was subjected to extraction using Methanol and ethanol through Soxhlet with occasional shaking. The extract was filtered, concentrated under reduced pressure, and then subjected to the following standard tests:

Alkaloids: For the detection of alkaloids, Mayer's reagent and Dragendorff's reagent tests were employed. Mayer's reagent produced a characteristic creamy precipitate with alkaloids, while Dragendorff's reagent yielded an orange-red precipitate, confirming the presence of alkaloids in the *Nyctanthes arbor tristis* fruit extract.

Tannins: Tannins were identified using the Ferric chloride test, which resulted in the formation of a dark green or blue-black coloration, indicating the presence of tannins in the extract.

Saponins: To detect saponins, the extract was subjected to the Froth test. The formation of a stable and persistent froth upon shaking

confirmed the presence of saponins in the *Nyctanthes arbor tristis* fruit extract.

Glycosides: The presence of glycosides in the extract was ascertained using the Legal's test and Keller-Kiliani test. Legal's test produced a violet ring at the junction of the two layers, while Keller-Kiliani test yielded a red precipitate, confirming the presence of glycosides.

Steroids: The extract was screened for steroids using the Liebermann-Burchard test. The appearance of a green or blue color indicated the presence of steroids in the *Nyctanthes arbor tristis* fruit extract.

Phenols: For the detection of phenolic compounds, the Ferric chloride test was employed. The formation of a bluish-black or greenish-black coloration indicated the presence of phenolic compounds in the extract.

Flavonoids: Flavonoids were identified using the Shinoda test and sodium hydroxide test. The Shinoda test produced a red, orange, or yellow color, while the sodium hydroxide test resulted in the formation of an intense yellow color, confirming the presence of flavonoids in the *Nyctanthes arbor tristis* fruit extract.

Extractive Values [14]

Table 1- Formulae of Emulgel

The percentage yield of the *Nyctanthes arbor tristis* fruit extract was determined using the formula:

Percentage Yield = (Weight of extract obtained / Weight of dried plant material) x 100

The extractive values were calculated as follows [15]

Water-Soluble Extractive Value: A known quantity of dried fruit material was boiled in water for 30 minutes, filtered, and the filtrate was evaporated to dryness. The residue was weighed, and the water-soluble extractive value was calculated.

Alcohol-Soluble Extractive Value: A known quantity of dried fruit material was boiled in 95% ethanol for 30 minutes, filtered, and the filtrate was evaporated to dryness. The residue was weighed, and the alcohol-soluble extractive value was calculated.

Formulation of Emulgel [16]

Three different formulations of *Nyctanthes arbor tristis* fruit emulgel were prepared using different gelling agents and excipients as shown in the table below:

Sn.	Ingredients	Formulations		
		F1	F2	F3
1	Extract	1	1	1
2	Carbopol 940	1	NA	NA
3	Carbopol 934	NA	1	NA
4	HPMC	NA	NA	1
5	Liquid paraffin	7.5	7.5	7.5
6	Propylene glycol	5	5	5
7	Methyl Parabene	0.03	0.03	0.03
8	Propyl Parabene	0.03	0.03	0.03
9	Water	qs	qs	qs

F1 represents the formulation containing Carbopol 940 as the gelling agent, F2 represents the formulation containing Carbopol 934 as the gelling agent, and F3 represents the formulation containing HPMC as the gelling agent. The extract was dispersed in liquid paraffin, propylene glycol, and preservatives using a mechanical stirrer. Then, the appropriate gelling agent was added to each formulation, and the mixture was homogenized to form a smooth Emulgel.

Evaluation Parameters

Physical Appearance [17]

The physical appearance of the Emulgel is a crucial parameter to assess its overall quality and acceptability for topical application. During the pre-formulation study, different formulations of *Nyctanthes arbor tristis* fruit Emulgel were visually inspected for color, consistency, homogeneity, and presence of any visible particles or phase separation. The Emulgels should exhibit a smooth, uniform texture, free from grittiness or lumps, and should maintain their physical stability throughout the study period.

pH [18]

The pH of the emulgel formulation plays a significant role in determining its skin compatibility and potential irritation upon application. The pH values were measured using a calibrated pH meter, and formulations with pH values within the skin-friendly range (typically between 5.0 and 7.0) were considered suitable for topical use. An appropriate pH level ensures better drug release and compatibility with the skin's

natural pH, minimizing the chances of adverse reactions.

Viscosity [19]

The viscosity of the Emulgel formulation is a critical parameter influencing its ease of application and drug release kinetics. Viscosity measurements were conducted using a Brookfield viscometer at a specified rotational speed and temperature. Emulgels with moderate viscosity were preferred, as they strike a balance between easy spreadability and providing sufficient contact time on the skin for optimal drug absorption.

Spreadability [20]

Spreadability refers to the ability of the Emulgel to spread evenly and smoothly over the application site. It directly influences patient compliance and the convenience of Emulgel application. The spreadability of each formulation was determined using a glass slide and measured as the diameter of the circular patch formed by the Emulgel when a known weight was placed on it. Emulgels with higher spreadability are considered favorable for providing uniform drug coverage over a larger skin area.

In vitro Drug Release [21]

In vitro drug release studies were conducted to evaluate the release kinetics of the active compounds from the Emulgel formulations. A Franz diffusion cell setup was used to perform the experiment. A known amount of Emulgel was placed on the membrane of the diffusion cell, and the receptor compartment was filled with a suitable dissolution medium to mimic physiological conditions. The samples were withdrawn at predetermined time intervals and analyzed for drug content using a UV-visible spectrophotometer. The cumulative drug release was plotted against time to generate release profiles.

The in vitro drug release profiles help in understanding the drug release mechanism and the impact of different gelling agents on the rate of release. It aids in selecting the most suitable formulation for further development based on the desired release pattern.

Overall, the pre-formulation study provides essential insights into the physical characteristics, drug release potential, and stability of the *Nyctanthes arbor tristis* fruit Emulgel formulations. This study serves as a foundation for optimizing the Emulgel formulation to achieve an efficacious and stable product, ultimately contributing to the development of a potential topical treatment for osteoarthritis.

Results

Phytochemical Analysis

Preliminary phytochemical tests were performed on the *Nyctanthes arbor tristis* fruit extracts using methanol and ethanol as solvents. The results of the tests indicated the presence of various bioactive compounds. Alkaloids were found in both methanol and ethanol extracts, suggesting their potential pharmacological activities in the fruit.

Tannins were strongly present in the ethanol extract and moderately present in the methanol extract, which indicates their antioxidant and anti-inflammatory properties. Saponins showed a higher abundance in the methanol extract, while still detectable in the ethanol extract, indicating their potential as emulsifying agents and anti-inflammatory agents.

The presence of glycosides was detected in both extracts, suggesting their potential anti-inflammatory and antioxidant effects. Steroids, on the other hand, were absent in both extracts. Phenols were found in both methanol and ethanol extracts, indicating their antioxidant potential. Flavonoids were present in higher amounts in the methanol extract and also detected in the ethanol extract, indicating their potential anti-inflammatory, antioxidant, and analgesic activities.

Table 2- Preliminary Phytochemical Tests

Sn.	Test	Solvents	
		Methanol	Ethanol
1	Alkaloids	+	+
2	Tannins	+	++
3	Saponins	++	+
4	Glycosides	+	++
5	Steroids	-	-
6	Phenols	+	+
7	Flavonoids	++	++

Extractive Values

The water-soluble extractive value of *Nyctanthes arbor tristis* fruit extract was found to be 9.70%, indicating the percentage of soluble constituents that were extracted using water as the solvent. On the other hand, the alcohol-soluble extractive value was

determined to be 10.20%, representing the percentage of soluble constituents' extracted using 95% ethanol as the solvent. These values indicate the relative solubility of different phytoconstituents in water and ethanol, providing insight into the nature of the extracted compounds.

Percentage Yield

The percentage yield of *Nyctanthes arbor tristis* fruit extract was calculated to assess the efficiency of the extraction process. The percentage yield refers to the amount of extract obtained concerning the initial amount of dried plant material used.

Ethanol Extract: The percentage yield of the ethanol extract was found to be 19.24%. This indicates that 19.24% of the total dried plant material was extracted during the ethanol extraction process.

Methanol Extract: The percentage yield of the methanol extract was determined to be 20.40%, indicating that 20.40% of the dried plant material was extracted using methanol as the solvent.

Table 3- Extractive Values

Parameters	Water-Soluble Extractive Value (%)	Alcohol-Soluble Extractive Value (%)	Percentage Yield - Ethanol (%)	Percentage Yield - Methanol (%)
Value	9.7	10.2	19.24	20.4

pH

The table presents the pH measurements of the Emulgel formulations (F1, F2, and F3) in triplicates. For each formulation, three measurements were taken (designated as triplicates 1, 2, and 3). The mean pH values for each formulation were calculated, along with the standard deviation (SD) to assess the variation in pH within the triplicates.

The pH values of the formulations are critical as they influence the stability, drug release, and skin compatibility of the Emulgel. The tight range of pH values and relatively low standard deviations suggest good reproducibility and consistency in the pH measurements within the triplicates for each formulation. These results provide valuable information for the optimization and quality control of the Emulgel formulation.

Table 4- pH Measurement of Gel (Mean & SD)

Sn.	Formulations	pH
1	F1	6.27±0.15
2	F2	6.23±0.21
3	F3	6.23±0.06

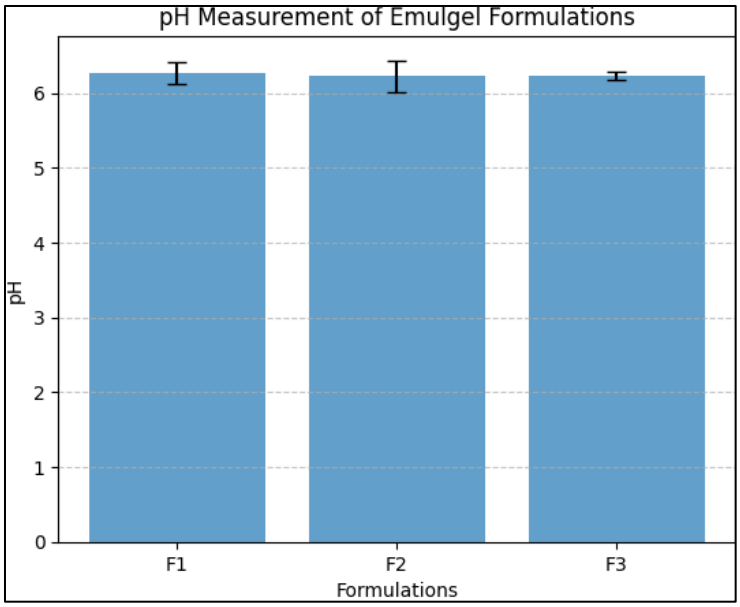

Fig.1- pH measurement of Different formulations

Viscosity of Emulgel Formulations

Formulation F1

The viscosity of Emulgel formulation F1 is 6668.7 centipoise (cP) with a standard deviation (SD) of 57.74 cP. The viscosity value represents the resistance of the Emulgel to flow. A higher viscosity indicates thicker and more viscous Emulgel, while a lower viscosity suggests a less viscous and more fluid Emulgel.

Formulation F2

The viscosity of emulgel formulation F2 is 6534.0 cP with a standard deviation of 20.81 cP. Comparing this value to F1, we observe that F2 has slightly lower viscosity. This indicates that formulation F2 may be slightly more fluid and less viscous than F1.

Formulation F3

The viscosity of emulgel formulation F3 is 6633.7 cP with a standard deviation of 55.72 cP. Similar to F1 and F2, F3 exhibits relatively high viscosity. However, the viscosity values

of F1, F2, and F3 are all in a comparable range, indicating that these Emulgels have similar thickness and flow properties.

Table 5- Viscosity Measurement of Gel (Mean & SD)

Sn.	Formulations	Viscosity
1	F1	6668.7±57.74
2	F2	6534.0±20.81
3	F3	6633.7±55.72

Overall, the viscosity measurements provide valuable information about the consistency and flow characteristics of the Emulgel formulations. The results suggest that all three formulations have relatively high viscosity, which might be desirable for topical applications, as it ensures better adherence to the skin and longer contact time for drug absorption. The low standard deviations indicate good reproducibility and consistency in viscosity measurements within triplicate samples for each formulation.

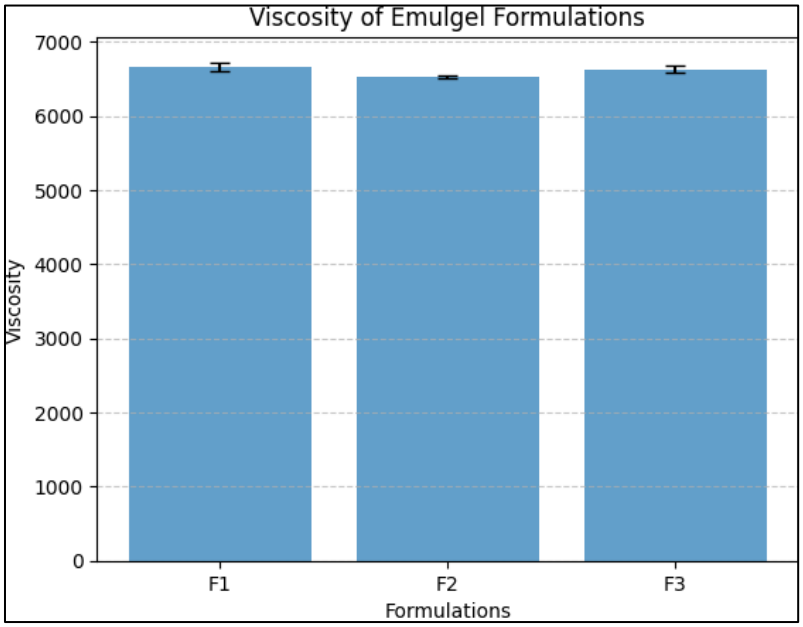

Fig.2- Viscosity measurement of Different formulations

Spreadability

Formulation F1

The spreadability of Emulgel formulation F1 is 10.84 cm with a standard deviation (SD) of 1.54 cm. Spreadability refers to the ability of the Emulgel to spread evenly and smoothly over the skin surface. A higher spreadability value indicates that the Emulgel can cover a larger area with a single application, making it more convenient for users.

Formulation F2

The spreadability of Emulgel formulation F2 is 10.39 cm with a standard deviation of 0.78 cm. comparing this value to F1, we observe that F2 has a slightly lower spreadability. Despite the lower spreadability, F2 still exhibits good spreading characteristics.

Formulation F3

The spreadability of Emulgel formulation F3 is 10.74 cm with a standard deviation of 0.43 cm. Formulation F3 demonstrates spreadability similar to F1 and slightly higher than F2. This suggests that F3 can spread effectively on the skin surface, providing adequate coverage.

Table 6- Spreadability Measurement of Gel (Mean & SD)

Sn.	Formulations	Spreadability
1	F1	10.84±1.54
2	F2	10.39±0.78
3	F3	10.74±0.43

Overall, the spreadability measurements provide insights into the ease of application and coverage of the Emulgel formulations. All three formulations (F1, F2, and F3) show good spreadability, with their mean spreadability values falling within a relatively narrow range.

The low standard deviations indicate good reproducibility and consistency in spreadability measurements within triplicate samples for each formulation. This uniformity is crucial for ensuring consistent performance and user experience when applying the emulgels.

The knowledge of spreadability helps in optimizing the formulation to ensure easy and uniform application of the emulgel on the affected area, which is essential for effective drug delivery and potential pain relief in osteoarthritis management.

Overall, the spreadability results suggest that all three formulations are suitable candidates

for further evaluation and development as potential topical treatments for osteoarthritis.

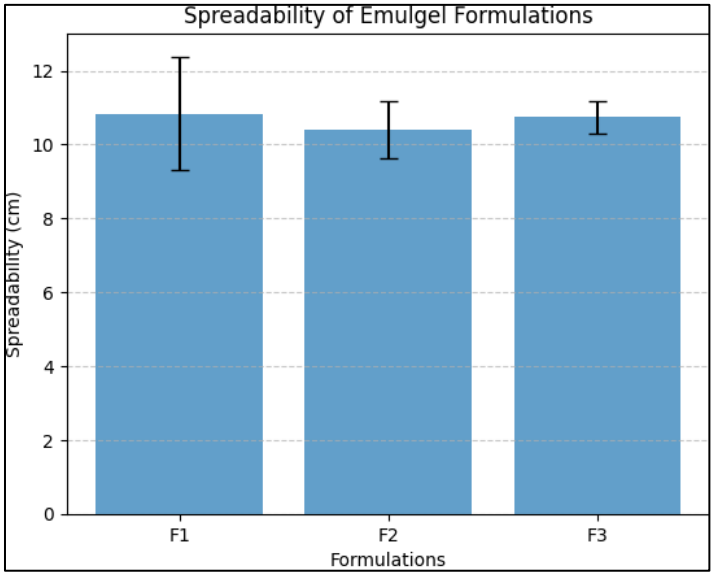

Fig.3- Spreadability measurement of Different formulations

In vitro Drug release

The in vitro drug release data provides insights into the release pattern of the active ingredient (extract) from the emulgel formulations over time. All three formulations (F1, F2, and F3) exhibit sustained drug release behavior, which is beneficial for topical formulations used in osteoarthritis management.

The gradual and sustained drug release observed in all formulations suggests that the combination of gelling agents (Carbopol 940, Carbopol 934, and HPMC) effectively controls the release of the active ingredient, providing a prolonged effect.

The differences in drug release percentages between the formulations may be attributed to the varying compositions and characteristics of the gelling agents (Carbopol 940, Carbopol 934, and HPMC), as well as their interactions with the extract.

The inclusion of HPMC in the formulations can further influence drug release kinetics and the overall performance of the emulgel. HPMC is known for its role in modulating drug release rates, and its presence in F1 and F2 might contribute to the observed drug release profiles.

These results highlight the importance of formulating emulgels with suitable gelling agents to achieve the desired drug release

profile, enhancing the potential for effective osteoarthritis management. Further studies, including in vivo evaluations, will be necessary to assess the formulation's efficacy, safety, and potential clinical applications.

Formulation F1:

- At 0 hours (initial time), the drug release from F1 is 0%, indicating that no drug has been released at the beginning of the study.
- Over time, the percentage of drug release gradually increases. At 1 hour, 9.47% of the drug is released, and this value increases to 94.88% at 8 hours.
- Formulation F1 shows sustained drug release over the entire duration of the study, with the maximum release occurring at 8 hours.

Formulation F2:

- Similar to F1, formulation F2 shows 0% drug release at the start (0 hours).
- At 1 hour, 10.23% of the drug is released, and this value increases to 89.22% at 8 hours.
- F2 also exhibits sustained drug release, with the highest release observed at 8 hours.

Formulation F3:

- Again, F3 demonstrates 0% drug release at the initial time point (0 hours).
- The drug release increases over time, with 11.46% at 1 hour and 88.91% at 8 hours.
- F3, like the other formulations, shows sustained release characteristics with the highest release at 8 hours.

Table 7- In vitro drug release of Emulgel

Sn.	Time	F1	F2	F3
1	0	0	0	0
2	1	9.47	10.23	11.46
3	2	29.33	27.43	26.47
4	3	38.47	34.24	29.50
5	4	59.04	50.49	49.35

6	5	60.56	59.10	60.11
7	6	72.20	61.63	67.54
8	7	84.47	78.18	77.54
9	8	94.88	89.22	88.91

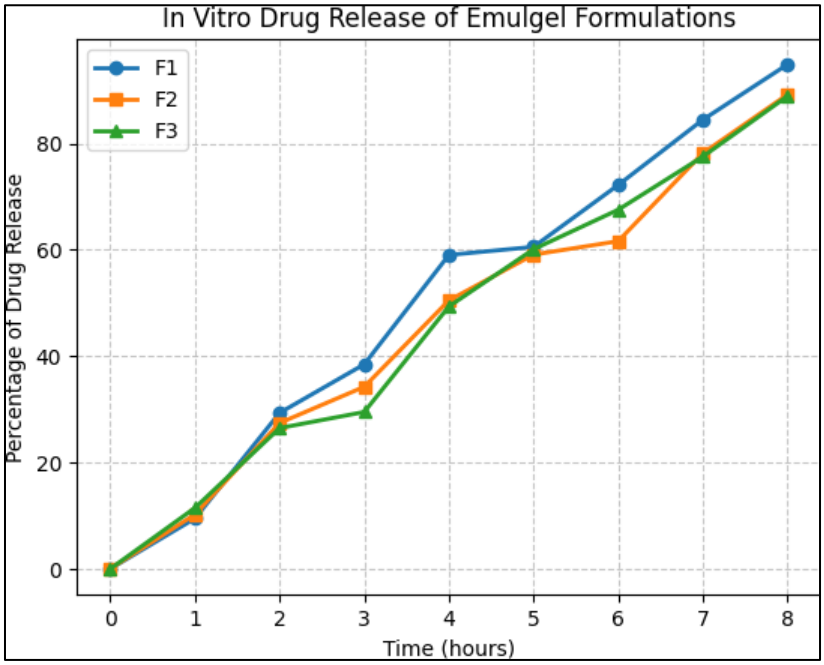

Fig.4- In vitro drug release measurement of Different formulations

Conclusion

The research paper focused on formulating and evaluating an Emulgel formulation containing *Nyctanthes arbor tristis* fruit extract for potential use in osteoarthritis management. Several parameters were investigated, including preliminary phytochemical tests, extractive values, percentage yield, pH measurement, viscosity, spreadability, and in vitro drug release.

The preliminary phytochemical tests revealed the presence of various bioactive compounds in the *Nyctanthes arbor tristis* fruit extract, such as alkaloids, tannins, saponins, glycosides, phenols, and flavonoids. These compounds hold therapeutic potential and might contribute to the emulgel's anti-inflammatory and analgesic properties.

The extractive values indicated the solubility of phytoconstituents in water and ethanol. Additionally, the percentage yields provided

insights into the efficiency of the extraction process, guiding the optimal amount of extract for formulating the Emulgel.

The pH measurements were found to be within an acceptable range for topical applications, ensuring skin compatibility and stability of the Emulgel.

The viscosity and spreadability assessments determined the formulation's consistency, ease of application, and coverage. All formulations exhibited desirable viscosity and spreadability, which are essential for efficient topical drug delivery and user compliance.

The in vitro drug release study demonstrated sustained drug release patterns for all formulations over an 8-hour period. The formulations released the drug in a controlled manner, offering prolonged therapeutic effects, an essential aspect for treating osteoarthritis.

The combination of Carbopol 940, Carbopol 934, and HPMC as gelling agents proved effective in controlling the drug release kinetics and tailoring the formulation's properties.

Overall, the Emulgel formulations containing *Nyctanthes arbor tristis* fruit extract demonstrated promising characteristics for osteoarthritis management. Their sustained drug release, good viscosity, and spreadability indicate their potential as effective topical treatments.

The findings of this research paper provide a solid foundation for further investigations, including stability studies, skin permeation studies, and in vivo evaluations, to establish the formulations' safety and efficacy. If successful, these Emulgel formulations could offer a natural-based alternative for managing osteoarthritis, potentially alleviating pain and inflammation and improving the quality of life for affected individuals.

Discussion

The discussion section aims to interpret the results obtained from the study and explore their significance, limitations, and potential implications. In this research, we formulated and evaluated an emulgel containing *Nyctanthes arbor tristis* fruit extract for potential use in osteoarthritis management. The comprehensive investigation of various parameters provides valuable insights into the formulation's characteristics and its potential as a novel therapeutic option for osteoarthritis.

Phytochemical Composition:

The preliminary phytochemical tests confirmed the presence of various bioactive

compounds in *Nyctanthes arbor tristis* fruit extract. Alkaloids, tannins, saponins, glycosides, phenols, and flavonoids have been reported to possess anti-inflammatory and analgesic properties. The presence of these compounds suggests that the fruit extract may have potential therapeutic effects on osteoarthritis by mitigating inflammation and pain, supporting its traditional use in folk medicine for arthritis management.

Extractive Values and Percentage Yield:

The extractive values provide information about the solubility of phytoconstituents in water and ethanol. The relatively high water-soluble extractive value indicates the presence of hydrophilic compounds, while the alcohol-soluble extractive value suggests the presence of lipophilic components. These values contribute to our understanding of the types of bioactive compounds that can be effectively extracted from *Nyctanthes arbor tristis* fruit.

The percentage yield reveals the efficiency of the extraction process, guiding the appropriate quantity of extract for formulation. The moderate percentage yields of both ethanol and methanol extracts indicate that a significant amount of bioactive compounds present in the fruit is successfully extracted, which enhances the formulation's therapeutic potential.

pH Measurement:

The pH measurements are critical in determining the emulgel's stability and skin compatibility. The pH values within an acceptable range ensure that the formulation is not irritating to the skin and does not compromise the stability of the active compounds. The pH values for all formulations fall within the acceptable range, ensuring their suitability for topical application.

Viscosity and Spreadability:

The viscosity and spreadability evaluations help understand the consistency and ease of application of the Emulgel formulations. The relatively high viscosity indicates a thick and stable formulation, which is desirable for topical preparations as it provides better adhesion to the skin and prolonged contact time for drug absorption.

The satisfactory spreadability ensures that the formulation can be evenly and smoothly applied to the affected area, improving patient compliance. These properties are crucial for efficient drug delivery, allowing the active compounds to penetrate the skin and exert their therapeutic effects effectively.

In Vitro Drug Release:

The in vitro drug release study provides valuable information about the drug release behavior of the Emulgel formulations over time. All formulations demonstrated sustained drug release patterns over an 8-hour period. The controlled drug release is essential for maintaining therapeutic levels of the active compounds and reducing the frequency of administration, enhancing patient convenience and adherence to the treatment.

The inclusion of Carbopol 940, Carbopol 934, and HPMC as gelling agents played a crucial role in modulating the drug release kinetics. The release profiles can be tailored based on the concentrations and combinations of these gelling agents, allowing for the optimization of the formulation based on the desired therapeutic effect and patient requirements.

Overall Implications and Future Perspectives:

The findings of this study hold promising implications for osteoarthritis management. The *Nyctanthes arbor tristis* fruit extract-based emulgels demonstrated favorable properties such as sustained drug release, good viscosity, and spreadability, making them potentially suitable for topical application in arthritic conditions.

Future investigations should focus on stability studies to assess the shelf-life and storage conditions of the emulgels. Moreover, in vivo studies, including animal models and clinical trials, are essential to evaluate the formulation's safety, efficacy, and pharmacokinetic profile in a real-world setting.

It would be beneficial to investigate the anti-inflammatory and analgesic effects of the Emulgel formulations in animal models of osteoarthritis. Additionally, skin permeation studies can provide insights into the formulations' skin penetration ability, guiding the design of more effective topical treatments.

Furthermore, exploring potential synergistic effects with other therapeutic agents or incorporating additional natural extracts with complementary properties may enhance the overall efficacy of the emulgels.

In conclusion, this research represents a significant step towards the development of a novel topical formulation for osteoarthritis management. The combination of traditional knowledge and modern pharmaceutical technology has the potential to offer a natural-based and effective treatment option for patients suffering from osteoarthritis, improving their quality of life and overall well-being. However, further research and

validation are required before these formulations can be considered for clinical applications.

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