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EXPLORING ANTI-INFLAMMATORY PROPERTIES AND PHYTOCHEMICAL COMPOSITION OF NYCTANTHES ARBOR-TRISTIS: A COMPREHENSIVE REVIEW

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Abstract:

Scientific studies provide compelling evidence supporting *Nyctanthes arbor-tristis* as an Ayurvedic medicinal plant, with traditional healers suggesting its leaves contain anti-inflammatory agents that could aid with treating conditions like arthritis and gout; however, more clinical data must be presented to verify these claims. Recent research has examined the anti-inflammatory properties of *Nyctanthes arbor-tristis*. An in-depth examination of its leaves identified multiple compounds with potential anti-inflammatory activities; of these compounds, Lupeol showed intense inhibitory action by stopping the production of proinflammatory cytokines; these results indicate that *Nyctanthes arbor-tristis* may serve as an effective therapy to address inflammation-based disorders like arthritis. At this juncture, evidence demonstrating *Nyctanthes arbor-tristis*' therapeutic potential and anti-inflammatory effects warrant further examination. Additional clinical research must also occur to fully understand these mechanisms and establish their safety and efficacy within clinical environments.

Keywords: *Nyctanthes arbor-tristis*, anti-inflammatory, medicinal plant, Ayurvedic medicine, arthritis, gout, inflammation, traditional healers.

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INTRODUCTION

The *Nyctanthes arbor-tristis* is an evergreen tree. The tree grows to a height of 5-15m and has fragrant white flowers that bloom in the evening [1]. The tree is also known as the night-flowering jasmine or the Parijata tree. They are native to tropical and subtropical Asia, including India, Sri Lanka, Malaysia, Indonesia, the Philippines and Vietnam [2].

The flowers have a sweet fragrance and are used in religious ceremonies and traditional medicine [2]. The *Nyctanthes arbor-tristis* is also known as the "Tree of Sorrow" because its flowers bloom at night and fall off by morning, symbolising the transitory nature of life [3].

The *Nyctanthes arbor-tristis* has many medicinal properties and is used in Ayurvedic and Chinese medicine. These systems have been used for centuries and have stood the test. They are based

on the 'prevention is better than cure' principle. These systems promote health and well-being rather than merely treating disease [4].

They emphasise a holistic approach to health, considering an individual's physical, mental and emotional aspects. This helps in providing more complete and comprehensive care [5]. Unani and Ayurveda medicines are safe and effective, with minimal side effects. They are readily available and affordable, making them accessible to all. These factors make traditional systems of medicine an attractive option for healthcare. The tree leaves are used to treat fevers, diarrhoea, and dysentery. The bark is used to treat skin diseases [6].

These systems of medicine have been in practice for centuries and have evolved. They have a rich history and heritage and continue to be relevant in today's world. These systems offer a unique perspective on health and illness and provide valuable tools for preventing and treating disease [7].

Nyctanthes arbor-tristis has been traditionally used to treat various inflammatory disorders. The plant extract suppresses the production of pro-inflammatory cytokines and mediators [8]. It also inhibits the activation and proliferation of immune cells. *Nyctanthes arbor-tristis* is a traditional medicinal plant used in the Indian subcontinent to treat inflammatory conditions. [9]

The leaves and flowers of *Nyctanthes arbor-tristis* are rich in alkaloids, flavonoids, terpenoids, and saponins, which are known to have anti-inflammatory activity. Aqueous extracts of the leaves and flowers of *Nyctanthes arbor-tristis* have been shown to inhibit the release of pro-inflammatory mediators from lipopolysaccharide (LPS)-stimulated macrophages [10].

Additionally, the extracts have modulated the expression of pro-inflammatory genes such as tumour necrosis factor-alpha (TNF-alpha) and interleukin-1 beta (IL-1 beta). These findings suggest *Nyctanthes arbor-tristis* may be a potential herbal remedy for treating inflammatory diseases [11]. These molecules have been shown to possess various health-promoting properties, including anti-inflammatory effects. Several mechanisms have been proposed to explain the anti-inflammatory activity of polyphenols, including the inhibition of pro-inflammatory enzymes, the scavenging of reactive oxygen species, and the modulation of immune cell function. Clinical studies examining the effect of polyphenol-rich foods on inflammation have generally shown positive results, although more research is needed in this area [12].

MORPHOLOGY

Leaves

The leaves are simple, opposite and decussate, with elliptical to obovate shapes that are 6-12 cm long and 3-6 cm wide. The margins are entire or slightly toothed, and the apex is acute to obtuse [13]. The upper surface of the leaves is glabrous, while the lower surface is covered in soft, silky hairs. The petioles are 0.5-2 cm long and stout, while the stipules are lanceolate to ovate and measure 1-3 cm in length [14].

Flower

The flowers of *Nyctanthes arbor-tristis* are borne in axillary, solitary or paired inflorescences. The pedicel is 3-4 cm long [13]. The calyx is campanulate, with five ovate, acuminate lobes. The corolla is white, tubular-funnel shaped, about 5 cm long and 2.5 cm across at the mouth. There are five stamens inserted near the base of the corolla tube. The ovary is superior and consists of two fused carpels [15].

Fruits

The fruit of *Nyctanthes arbor-tristis* is a small, dark brown berry. The size of the fruit varies depending on the variety but is typically around 1 cm in diameter. The surface of the fruit is covered in tiny bumps, and a small stalk is attached to the base. The fruit's flesh is thin and contains a single seed [16].

Bark

The Bark of *Nyctanthes arbor-tristis* L. is generally dark brown but can vary from light grey to almost black. Its bark is thick, corky, and brown in colour. The makeup of the bark consists of an inner cortex with an outermost layer of corking material [17].

Etymology

The Parijata tree is a divine tree that is found in heaven. It is also known as the 'Tree of Heaven'. The tree is beautiful and has fragrant flowers. The flowers are white and have five petals. They bloom at night and emit a sweet fragrance [18].

The Parijata tree is sacred in Indian mythology. It is known as Parijata because it originated in the Samudra (Ocean) due to (parinaha) thorough searching. The tree was brought to Indra's heaven by Krishna and Balarama [19].

Scientific Classification

The *Nyctanthes arbor-tristis* is a member of the Plantae kingdom and the Magnoliophyta division. It is classified under the Magnoliopsida class, Lamiales order, arbour-tristis species, Oleaceae family, and the Nyctanthes genus [20].

Kingdom:	**Plantae**
Clade:	**Tracheophytes**
Clade:	**Angiosperms**
Clade:	**Eudicots**
Clade:	**Asterids**
Order:	**Lamiales**
Family:	**Oleaceae**
Tribe:	**Myxopyreae**
Genus:	**Nyctanthes L.**

Fig.-1 Scientific classification of *Nyctanthes Arbortristis* [21]

PHYTOCHEMICAL PROFILE

The leaves of *Nyctanthes arbor-tristis* are a rich source of phytochemicals. The major compounds present in the plant include alkaloids, flavonoids, saponins, and tannins [22]. These phytochemicals have been shown to possess a wide range of biological activities, including antioxidant, anti-inflammatory, and antimicrobial activities. Additionally, the plant contains high levels of vitamins A and C, essential for human health [23].

Alkaloids

Alkaloids are naturally occurring nitrogen-containing organic compounds recognised for their pharmaceutical effects, with several identified in *Nyctanthes arbor-tristis* plants such as arbortristoside A and B. These compounds exhibit various bioactivities, including anti-inflammatory, analgesic, antipyretic and antimalarial properties that contribute to *Nyctanthes arbor-tristis*' traditional use in treating fever, pain and inflammation [24]. The presence of these alkaloids explains their effectiveness as pain relievers and providing antimalarial properties. Alkaloids from *Nyctanthes arbor-tristis* plants have proven themselves promising natural sources for creating novel therapeutic agents against infectious diseases such as malaria. Furthermore, due to the variety of biological activities demonstrated by its alkaloids, further research must be conducted to understand their mechanisms of action and potential medical applications [25].

Iridoids

Iridoids are a class of monoterpenoids found in various plants such as *Nyctanthes arbor-tristis*. They possess numerous biological activities, including anti-inflammatory, antioxidant and antimicrobial activities that may aid their beneficial properties [26]. *Nyctanthes arbor-tristis* contains various iridoids such as nyctanthoside and deacetylnyctanthoside that have been reported to exhibit multiple therapeutic benefits, including protection from liver damage, modulating immune system responses and inhibiting cancer cell growth. *Nyctanthes arbor-tristis*' high concentration of iridoids plays an integral part in its traditional use for treating liver disorders, inflammation and infections. Their various bioactivities have inspired further studies and research regarding their potential as natural resources to create novel drugs or therapeutic agents [27].

Flavonoids

Flavonoids are polyphenolic compounds known for their antioxidant and anti-inflammatory properties, making them critical components in *Nyctanthes arbor-tristis* plants. Some unique flavonoids in its stem include quercetin, kaempferol and their glycoside derivatives - these may even provide valuable medicinal applications! These compounds are critical in neutralising free radicals, decreasing oxidative stress levels and modulating inflammation pathways [28]. *Nyctanthes arbor-tristis* contains flavonoids that have long been used to treat various inflammatory conditions like arthritis and asthma. The antioxidant properties in Nyctanthes arbor-tristis flavonoids could contribute to potential neuroprotective benefits that could prove helpful in managing neurodegenerative diseases, while their vast array of biological activities warrants further examination to understand how they operate and their

potential applications in medicine [29].

Triterpenoids

Triterpenoids are naturally occurring compounds with numerous biological activities. Lupeol, a pentacyclic triterpenoid found in *Nyctanthes arbor-tristis* has been discovered and shown to exhibit anti-inflammatory effects. Lupeol has been shown to reduce the production of pro-inflammatory cytokines that play an integral part in various pathological conditions, such as arthritis and inflammatory bowel disease, by blocking their production [30]. These pro-inflammatory mediators play a significant role in chronic inflammation. *Nyctanthes arbor-tristis*' triterpenoids, such as Lupeol, have long been recognised for treating inflammation-related issues. Furthermore, these natural sources could provide new anti-inflammatory medication development avenues. Given these biological activities associated with *Nyctanthes arbor-tristis*' triterpenoids, it would be worthwhile conducting further studies into their mechanisms of action and therapeutic potential [31].

Essential Oils

Essential oils are volatile organic compounds derived from plant materials with various therapeutic benefits, making them popularly known in aromatherapy circles. *Nyctanthes arbor-tristis* leaves yield an essential oil rich in volatile components such as eugenol, methyl eugenol, b-caryophyllene and a-humulene that contribute to its aromatic and therapeutic qualities. These compounds contribute to both plants' aromatic and medicinal benefits [32]. *Nyctanthes arbor-tristis* essential oil has been reported as possessing antimicrobial, antioxidant and anti-inflammatory activities, making it suitable for combatting infections or speeding healing after wound injuries. The antimicrobial properties could prove particularly useful against infections while aiding wound recovery. Anti-inflammatory and antioxidant effects of *Nyctanthes arbor-tristis* essential oil may play an integral part in managing inflammation-related conditions and mitigating oxidative stress, respectively. More research must elucidate its therapeutic mechanisms and determine potential medical applications [33].

Phenolic compounds

Phenolic compounds are an extensive class of natural antioxidant substances found in various parts of nature, most notably in *Nyctanthes arbor-tristis* trees, where gallic acid, chlorogenic acid and caffeic acid have all been identified among several others as prominent phenolics. These compounds play a pivotal role in the medicinal benefits of plants by neutralising free radicals, alleviating oxidative stress and protecting cell components against damage. *Nyctanthes arbor-tristis*' presence of phenolic compounds has long been used in traditional medicinal practice to treat various conditions, including inflammation, fever and pain [34]. Pharnic compounds have shown great promise for treating chronic illnesses, such as cardiovascular and cancer, through their antioxidant and anti-inflammatory properties. More research must be conducted into their mechanism of action within *Nyctanthes arbor-tristis* flowers to understand better the potential therapeutic applications of their compounds [35].

Saponins

Saponins are an exciting group of glycosides known for their various biological activities, such as antimicrobial, antioxidant and immunomodulatory properties. *Nyctanthes arbor-tristis*

contains an unusual species with high concentrations of Oleanolic Acid Glycosides as part of their saponin content; one type has even been discovered within it [36]. *Nyctanthes arbor-tristis* contains saponins which contribute to its therapeutic benefits, including being traditionally utilised to treat respiratory and digestive ailments. Saponins have also been reported as having anticancer effects and modulating cholesterol levels to promote cardiovascular wellness, suggesting their use as anticancer agents. Given these biological activities demonstrated by *Nyctanthes arbor-tristis* saponins, more research needs to be conducted to understand their mechanisms of action and potential applications within medicine [37].

Phytochemical Class	Phytoconstituents
Steroids	β-sitosterol, Dmannitol β-sitosterole, Astragaline, Nicotiflorin, Oleanolic, acid, Nyctanthic acid, Tannic acid, Ascorbic acid, Methyl salicylate, Volatile oil Friedeline, Label Mannitol and Glucose
Alkaloids	Nyctanthine
Miscellaneous	Mannitol, Tannic acid, Ascorbic acid, methyl salicylate, traces of volatile oil, an amorphous resin, carotene, glucose, fructose, hexatriacontane, benzoic acid and benzoic ester of loganin
Glycosides	Eroded Glycosidesarborsides A, B, C, 6β-hydroxyloganin, Desrhamnosylverbacos ide, 6,7-DiObenzoylnycthanoside , 6-O-transcinnamoyl6β-hydroxyloganin, 7- Otrans-cinnamoyl-6βhydroxyloganin
Flavonoids	Nicotiflorin

Fig.-2 Phytochemical Profile of *Nyctanthes Arbortristis* [38, 39, 40]

TRADITIONAL USES OF *NYCTANTHES ARBOR-TRISTIS*

Plant parts	Chemical constituents
Leaves	D-mannitol, -sitosterole, astragaline, nicotiflorin, oleanolic acid, nyctanthic acid, tannic acid, ascorbic acid, methyl salicylate, carotene, friedeline, lupeol, mannitol, glucose and fructose, iridoid glycosides, benzoic acid.
Flowers	Essential oil, nyctanthin, d-mannitol, tannin and glucose, carotenoid, glycosides viz β-monogentiobioside ester of α-crocetin (or crocin-3), β-monogentiobioside-β-D monoglucoside ester of α-crocetin, β-digentiobioside ester of α-crocetin
Seeds	Arbortristoside A&B, Glycerides of linoleic oleic, lignoceric, stearic, palmitic and myristic acids, nyctanthic acid, 3-4 secotriterpene acid.
Stem	Glycoside-naringenin-4'-0-β-glucapyranosyl-α-xylopyranoside and β-sitosterol
Flower	Oil α-pinene, p-cymene, 1- hexanol methyl heptanone, phenyl acetaldehyde, 1-deconol and anisaldehyde.
Bark	Glycosides and alkaloids

Fig.3- Chemical constituents of *Nyctanthes Arbortristis*[41, 42, 43]

Leaves

D-mannitol and other phytochemicals present in *Nyctanthes arbor-tristis* have been demonstrated to have a role in the osmotic regulation of water uptake and distribution in the plant. This sugar alcohol is thought to regulate stomatal aperture, transpiration, and photosynthesis [44]. D-mannitol has also been shown to increase leaf area index (LAI), net CO2 assimilation rate (A), and stomata conductance (gS) in N. arbor-tristis.

Leaves of *Nyctanthes arbor-tristis* pharmacological properties have antidepressant, anti-inflammatory and analgesic activities. Ethanolic extract of *Nyctanthes arbor-tristis* leaves potentiated pentobarbitone-induced sleeping time in rats and mice. The study concluded that the sections have a central nervous system depressant effect [44].

Flower

The flowers of *Nyctanthes arbor-tristis* contain several phytochemicals shown to possess various pharmacological activities. These include flavonoids, tannins, saponins and alkaloids [32]. Flavonoids are known to possess antioxidant, anti-inflammatory and anti-cancer properties. Tannins are known for their astringent and antimicrobial properties. Saponins have been shown to include anti-inflammatory, immune stimulatory and anticancer activities. Alkaloids have been shown to possess analgesic, antipyretic and antispasmodic activities [45].

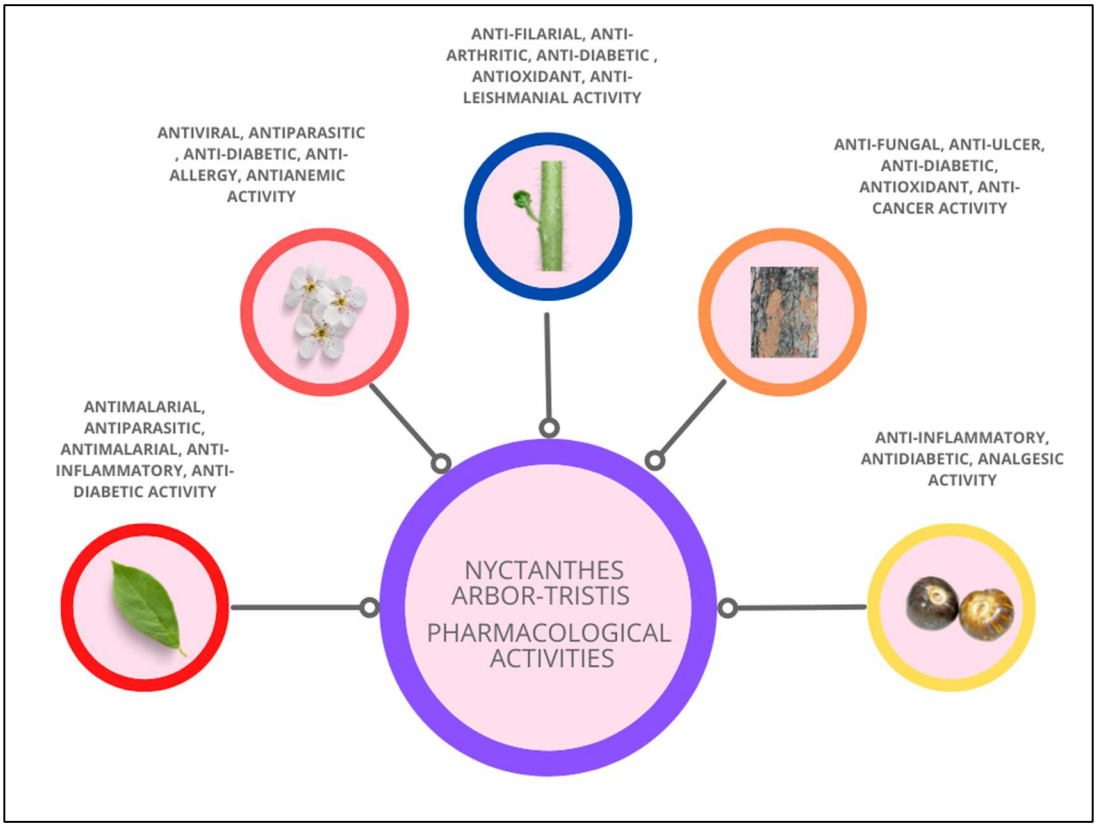

Fig.4- Nyctanthes Arbortristis Pharmacological Activities [44]

Seeds

Nyctanthes arbor-tristis seeds have been traditionally used in Indian and Chinese medicine for their analgesic, anti-inflammatory, and Antidiabetic properties [45]. The seeds contain several compounds shown to have these effects, including Arbortristoside A&B and Glycerides of linoleic oleic. Additionally, the seeds are a good source of protein and fibre. They can be eaten raw or roasted and are often used as a flavouring agent in curries and other dishes [46].

Stem

Nyctanthes arbor-tristis stem oil has been used in India to treat rheumatism and skin diseases [47]. The oil is prepared by steam distillation of the stem bark of the tree. The oil is yellow to brown in colour and has a strong, woody aroma. It is used in Ayurvedic medicine as a massage oil and is said to help relieve pain and inflammation [48].

Bark

Nyctanthes arbor-tristis bark has been used in Indian traditional medicine to treat various diseases and disorders. The bark contains tannins, flavonoids, alkaloids, saponins, and phenolic compounds [49]. These phytochemicals exhibit antimicrobial, anti-inflammatory, analgesic, antipyretic, and antioxidant activities. The bark has been used to treat diarrhea, dysentery, wounds, ulcers, skin diseases, fever, and cancer. It is also effective against malaria and dengue fever [50].

Nyctanthes arbor-tristis is an Ayurvedic herb used for centuries in India for its medicinal properties. The herb is known to possess anti-inflammatory, analgesic, and antipyretic qualities. It is also believed to help treat respiratory disorders, skin diseases, and digestive problems [51].

It has been used in Ayurvedic medicine for centuries. The most crucial pharmacological characteristic of *Nyctanthes arbor-tristis* is its rasa, which can be bitter, astringent, or pungent. Parijata is also said to have guna (quality), virya (potency), and vipaka (post-digestive effect) [52].

PHARMACOLOGICAL PROPERTIES

Plant-based diets have been shown to have anti-inflammatory effects. This may be because plants contain phytochemicals, natural compounds that benefit human health. Some phytochemicals, such as quercitin and Kaempferol, have anti-inflammatory properties. In addition, plant-based foods are generally high in fibre, which has also been shown to reduce inflammation [53].

Anti-inflammatory properties

Mousum S. A. et al. (2018) conducted a study examining the effects of *Nyctanthes arbor-tristis* on hyperglycemia and oxidative stress induced by the inflammatory cascade. The analysis was performed using diabetic rats with diabetes caused by a single injection of streptozotocin and a high-fat diet. After four weeks of experimentation, the results indicated that suppressing hyperglycemia was due to the reduction of oxidative stress and inflammatory cascades, along with the inhibition of NF-kB activation.

The study also revealed that a dose of 400 mg/kg could effectively reduce the activity of type-2 diabetes, including its inflammatory effects. The plant's gas chromatography and mass spectrophotometry analyses showed that specific phytochemicals present in *Nyctanthes arbor-tristis* are responsible for these activities. Consequently, the plant extract can potentially reduce inflammatory activities associated with diabetes.

This research contributes to the growing body of evidence supporting the therapeutic potential of *Nyctanthes arbor-tristis*, particularly in managing hyperglycemia and inflammation associated with type-2 diabetes. Further studies are needed to better understand the mechanisms behind these effects, isolate and characterise the active compounds, and evaluate the safety and efficacy of the extract in clinical settings [54].

Vijayalakshmi, S. and Ananthi, T. (2018) conducted an in-depth research project analysing the anti-inflammatory properties of *Nyctanthes arbor-tristis* plant (also referred to as Parijata). Their researchers assessed its anti-inflammatory activity by testing its bark's ethanolic extract. Initial screening for phytochemicals like alkaloids, flavonoids, glycosides and tannins indicated their presence within its composition of Bark.

Anti-inflammatory activity was evaluated using the albumin denaturation method with different concentrations of plant extract from *Nyctanthes arbor-tristis* bark extract at 50, 100, 200, 400 and 800ug/mL concentrations and dose-dependently demonstrated its anti-inflammatory activity; results indicate this might be attributable to flavonoids or quercetin within its structure.

Studies suggest that *Nyctanthes arbor-tristis* bark extract could be an anti-inflammatory agent,

providing additional evidence supporting its therapeutic use in anti-inflammatory settings. Further work must be conducted on understanding mechanisms, isolating active compounds, evaluating safety and efficacy, and clinical effectiveness of extract used in clinical settings [55].

Soubhagya, K. B. & Anilkumar, M. (2020) conducted a comprehensive examination of *Nyctanthes arbor-tristis* extract, revealing that its essential properties include anti-inflammatory and antioxidant activities. Regular use of allopathic drugs causes potential risks of toxicity or carcinogenicity within our bodies due to the various mechanisms of action involved; hence the basis for this research study lies within identifying mediators which respond to different Lysosomal enzymes while human Red Blood Corpuscles may interfere with anti-inflammatory mediator pathways to achieve results in finding answers about *Nyctanthes arbor-tristis* extract's fundamental properties.

This study further suggested that multiple phytochemical classes in various extracts might explain why certain plants exhibit anti-inflammatory effects. Extracts were produced using ethanol and water extractors; Diclofenac was chosen as a reference drug, and the activity was measured using ultraviolet-visible spectrophotometry at 200, 400, 600, and 800 1000uL concentrations of the solution, respectively.

These results demonstrate the efficacy of *Nyctanthes arbor-tristis* leaf and flower extracts on HRBC membrane protection, with Diclofenac as a reference drug showing significant stabilisation based on the concentration of flower extract. This adds further evidence to support its therapeutic potential - both anti-inflammatory and antioxidant. However, more research must be undertaken to understand the mechanisms behind such effects better and assess safety/efficacy issues in clinical environments [56].

Bordoloi, P., Devi, T., & Lahkar, M. (2018) Bordoloi, P., Devi, T. & Lahkar, M. (2018) conducted a study assessing the effectiveness of *Nyctanthes arbor-tristis* against traditional anti-inflammatory drugs. This plant has been utilised for centuries as an effective way of managing various inflammation- and arthritis-related ailments; an ethanolic extract was produced following OECD guidelines before an acute toxicological evaluation on animals was completed to ascertain its safety.

Animals were given carrageenan injections to induce inflammation by injecting it into their left paw. Evaluation of its anti-inflammatory effects was then measured according to various parameters, including edema, redness, locomotor activity and histopathology; Paw volumes were observed three days post-injection and 21st day with Aspirin being used as the standard comparison drug.

Results of the study demonstrated that *Nyctanthes arbor-tristis* extract could reduce inflammation in an animal's paw and enhance locomotor activity, suggesting it has anti-inflammatory properties that could be helpful when treating chronic inflammatory conditions [57].

Vishwakarma, R. K., Negi, A., & Negi, D. S. (2022) conducted a comprehensive investigation into the significant potential of the *Nyctanthes arbor-tristis* plant. The researchers prepared various extracts from the plant and evaluated their anti-inflammatory activity using an in vitro model for cyclooxygenase (COX) inhibition. Molecular docking studies revealed that the plant's leaves exhibited substantial potential in inhibiting COX-1 and COX-2 receptors. Specific phytochemicals, particularly those belonging to the flavonoid category, were found to be responsible for the anti-inflammatory effects and suppression of COX-1 inhibitors. The study determined the IC50 value, a measure of the effectiveness of a substance in inhibiting a specific biological function, which was found to be between 4.5 and 4.55 µg/mL.

These findings highlight the potential of *Nyctanthes arbor-tristis* in treating inflammatory conditions and provide a foundation for further research on the plant's bioactive compounds. Future studies could focus on isolating and characterising these flavonoids, understanding their mechanisms of action, and exploring their potential therapeutic applications in medicine [58].

CONCLUSION

Nyctanthes arbor-tristis is a traditional medicinal plant with great potential. The leaves, flowers and stem of this plant have many therapeutic uses. This herb effectively treats diseases and disorders like colds, coughs, fever, diarrhea, indigestion, and skin diseases. It is also used as a diuretic, expectorant and laxative agent. Further studies are needed to evaluate the safety and efficacy of this herb.

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