

NYCTANTHES ARBORTRITIS ETHNOPHARMACOLOGICAL NATURAL RESOURCE

LINN: AN
MIRACULOUS

Vikas Chauhan, Sanjita Das*, and Rohan Verma

Received: May 08, 2023; Revised: November 20, 2023; Accepted: November 27, 2023

Abstract

Nyctanthes arbortritis (Parijat tree) is a medicinal plant that has long been utilized in a variety of Ayurvedic formulations to treat a range of ailments. Many medicinal qualities like analgesic, antipyretic, antifungal, antibacterial, and anti-cancer properties, have been identified through comprehensive research on the pharmacological screening of *Nyctanthes arbortritis*. It has been demonstrated that the plant both inhibits the growth of certain cancer cells and has cytotoxic effects on them. As a promising therapy option for a range of inflammatory and pain related disorders, the extracts of its different plant parts have also been discovered to possess strong anti-inflammatory and analgesic activity. The plant extracts also have strong antifungal and antibacterial properties, which makes them a possible medicinal source for the creation of novel antibiotics. In this article, we have represented the collective scientific information about the various phytoconstituents and pharmacological activities of the *Nyctanthes arbortritis*.

Keywords: Anti-Inflammatory Activity; Glycosides; Immunomodulatory Activity; *Nyctanthes arbortritis*; Terpenoids

Introduction

The medicinal plant *Nyctanthes arbortritis*, also known as Night Jasmine, has been utilised extensively in traditional medical systems to treat a variety of illnesses. The plant is indigenous to the Indian subcontinent and belongs to the family Oleaceae. Greek, the terms “Nykhta” (night) and “anthos” (flower) were combined to create the Latin name *Nyctanthes* (Agrawal *et al.*, 2013). Numerous research have been done to look into the therapeutic potentiality of *Nyctanthes arbortritis* in light of the growing interest in the pharmacological actions of this plant in recent years. The plant’s medical

qualities are responsible for the presence of several bioactive substances, including iridoids, flavonoids, terpenoids, and alkaloids (Sarkar and Singh, 2022). Significant anti-inflammatory, analgesic, antipyretic, antibacterial, antifungal, and anti-cancer effects have been discovered in its plant extracts (Shinde *et al.*, 2014). These characteristics make *Nyctanthes arbortritis* a possible therapy option for a number of ailments (Sharma *et al.*, 2021b). Many of the medications used today have their roots in plant-derived chemicals, which have been utilised for therapeutic purposes for thousands of years (Jain

Department of Pharmacy, School of Medical and Allied Sciences, Galgotias University, India. E-mail: vc00340@gmail.com; sanjita8@yahoo.co.in*; rohanverma0105@gmail.com

* Corresponding author

DOI: <https://doi.org/10.55766/sujst-2023-06-e01198>

Suranaree J. Sci. Technol. 30(6):070072(1-10)

and Pandey, 2016). Secondary metabolites that are produced by plants include alkaloids, terpenoids, flavonoids, and phenolic chemicals, which have a variety of biological actions (Dewi *et al.*, 2022). Plants that contain chemicals with qualities such as antibacterial, anti-inflammatory, analgesic, antihypertensive, anti-cancer, and anti-diabetic are among those that are considered to be essential from a pharmacological standpoint. For instance, the willow tree (*Salix* spp.) bark contains salicylic acid, which is the precursor of aspirin, a commonly used pain reliever, and the opium poppy (*Papaver somniferum*), which yields the analgesic component morphine (Venkataraman *et al.*, 2019). We have collected the ethnopharmacological information about the miraculous medicinal natural source *Nyctanthes arbortritis* Linn as represented in those reviews and research articles.

It is a long-standing custom in many cultures to treat a wide range of diseases and health issues with plant-based medicines; for instance, both Ayurveda and Traditional Chinese Medicine (TCM) mainly rely on plant-based therapies supported by modern science (Barua *et al.*, 2023).

Drug leads-chemicals that provide the basis for the creation of new drugs have been abundantly found in compounds originating from plants. The Pacific yew tree's paclitaxel and the cinchona

tree's quinine are two well-known examples of medications that were first developed from plant-based substances (Dewi *et al.*, 2022).

Plants also produce compounds that have positive effects on health when included in the diet. These compounds are often referred to as nutraceuticals, and they include substances like polyphenols, carotenoids, and flavonoids. Some examples of plants with nutraceutical properties include blueberries, green tea, and turmeric (Amadarshanie *et al.*, 2022). Plant-derived chemicals have the potential to be used as medicines, but there are also substantial obstacles to overcome in the creation of these medications (Sarkar and Singh, 2022). For instance, many chemicals found in plants have complex structures that make them challenging to synthesize in a laboratory, and other plants may only produce small amounts of the desired component (Sharma *et al.*, 2021b). Furthermore, it can be challenging to predict the effectiveness and potential adverse effects of compounds produced from plants due to the fact that our understanding of how the body interacts with these substances is frequently inadequate (Rawat *et al.*, 2021). In the present study, an attempt has been made to include the whole past research on the valuable medicinal properties of *Nyctanthes arbortritis* for inventing with drug leads from its phytochemicals to get potent nutraceuticals and pharmaceuticals. This study highlights the potential therapeutic uses of *Nyctanthes arbortritis* while summarising the existing understanding of its pharmacological action and responsible phytoconstituents. It will be helpful for the researcher to get proper scientific information about the plant in a single article.

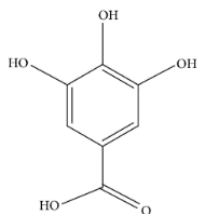


Figure 1. Chemical structures of Gallic acid

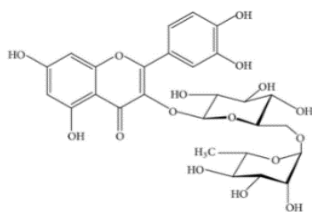


Figure 2. Chemical structures of Rutin

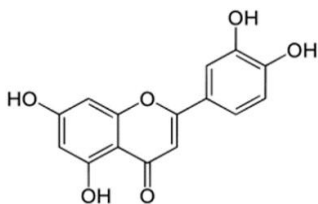


Figure 3. Chemical structures of Luteolin

Phytochemical Composition of *Nyctanthes arbortritis*

Phenolic compounds

Numerous phenolic substances, including as gallic acid (Figure 1), caffeic acid, and rutin (Figure 2), are present in *Nyctanthes arbortritis*. The anti-inflammatory and antioxidant characteristics of these chemicals are suggested to contribute to the medicinal effects of the plant (Dhinakaran and Sakthivel, 2016; Paikara *et al.*, 2021).

Flavonoids

Flavonoids such as luteolin (Figure 3), apigenin, and quercetin are among those found in *Nyctanthes arbortritis*. Numerous pharmacological benefits of flavonoids include their ability to reduce inflammation, act as antioxidants, and fight cancer. Additionally, they might act in a neuroprotective manner (Mishra *et al.*, 2016a).

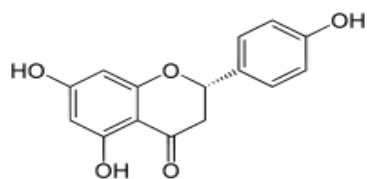


Figure 4. Chemical structures of Naringenin

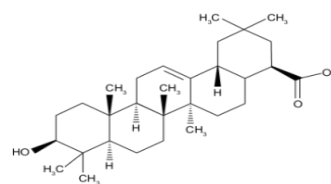


Figure 5. Chemical structures of Nyctanthic acid

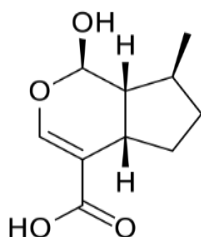


Figure 6. Chemical structures of 7-deoxyloganetic acid

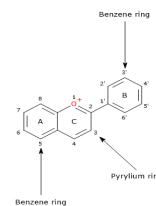


Figure 7. Chemical structures of Anthracyanin

Alkaloids

Several alkaloids, including naringenin (Figure 4) and hesperetin, are present in *Nyctanthes arborescens*. Alkaloids offer a variety of pharmacological effects like anti-inflammatory, anti-tumor, and anti-microbial potentiality. They might additionally have cardioprotective and neuroprotective properties (Chamoli *et al.*, 2019).

Glycosides

Natural substances known as glycosides can be found in a wide variety of plant species, including *Nyctanthes arborescens*. The compounds known as glycosides are made up of an anti-sugar (aglycone) and a sugar moiety (glycine) (Uroos *et al.*, 2017). Numerous glycosides have been discovered in *Nyctanthes arborescens*, including:

Nyctanthic acid (Figure 5) is a glycoside that has both a glucose moiety and an iridoid aglycone. It has a bitter flavor and exhibits anti-inflammatory properties, analgesic, and antipyretic properties.

Parijatosiside is a glycoside made up of a glucose moiety and a secoiridoid aglycone. It is said to have analgesic and antipyretic effects.

The glycoside 7-deoxyloganetic acid has an iridoid aglycone and a glucose moiety (Figure 6). It has been shown to have both analgesic and anti-inflammatory actions (Kim and Choi, 2021)

Lamiide is a glycoside made up of a glucose moiety and a phenylethanoid aglycone. Antioxidant and anti-inflammatory properties are attributed to it. Recently, arborescenside-A was also isolated from *Nyctanthes arborescens* seeds, and its structure was validated by X-ray crystallographic analysis (Gupta *et al.*, 2023).

Essential oils

Essential oils can be found in the leaves, flowers, and stems of *Nyctanthes arborescens*. These oils contain different terpenoids, including limonene, alpha-pinene, and beta-pinene, which help to create the plant's distinctive perfume. Due to their medicinal qualities, including their antibacterial, anti-inflammatory, and analgesic actions, essential oils have been employed (Jain and Pandey, 2016).

Anthocyanins: *Nyctanthes arborescens* contains anthocyanins (Figure 7), which are water-soluble pigments that give plants their red, purple, or blue color. These substances have anti-inflammatory and antioxidant attributes and they may provide beneficial health benefits by lowering the risk of long-term conditions like cancer and heart disease (Shaji *et al.*, 2022).

Tannins

Nyctanthes arborescens contains tannins (Figure 8), which are a group of compounds that can bind to and precipitate proteins. Tannins have astringent properties and have been used to treat diarrhea, inflammation, and bleeding. However, excessive consumption of tannins can also have negative effects, such as interfering with the absorption of iron and other minerals (Bijauliya *et al.*, 2021).

Quinones

Nyctanthes arborescens contains quinones (Figure 9), which are a group of compounds that have diverse pharmacological properties. Some quinones have been shown to have antitumor and antimicrobial properties, while others have been used as insecticides or components of traditional dyes (Sana *et al.*, 2023).

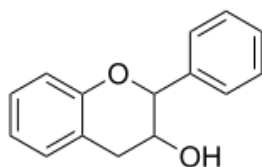


Figure 8. Chemical structures of Tannins

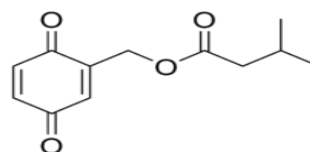


Figure 9. Chemical structures of Quinones

Terpenoids

Terpenoids are a class of widely dispersed chemical compounds in plants whose various pharmacological effects are well-known. Many terpenoids from *Nyctanthes arbortritis* have been discovered and isolated (Chamoli *et al.*, 2019). The following terpenoids have been linked to *Nyctanthes arbortritis*:

- The terpenoid beta-caryophyllene having analgesic and anti-inflammatory. The terpenoid alpha-humulene is well-known for having anti-inflammatory, analgesic, and antibacterial activity (Saha *et al.*, 2012).
- This terpenoid, known as germacrene-D, has antibacterial, antifungal, and insecticidal effects. The terpene linalool is well-known for its calming and anxiolytic effects. Eucalyptol is a terpenoid that has analgesic and anti-inflammatory effects. Camphene is a terpenoid that has been shown to have antibacterial and insecticidal effects.
- Alpha-terpinene is a terpenoid that has analgesic and anti-inflammatory effects. Beta-pinene is a terpene with antibacterial and insecticidal qualities (Chamoli *et al.*, 2019).

Pharmacological Activity of *Nyctanthes arbortritis*

Antibacterial Activity

Nyctanthes arbortritis is a plant that has been traditionally used for its antimicrobial properties. Antimicrobial activity refers to the ability of a substance to inhibit the growth or kill microorganisms such as bacteria, viruses, and fungi. The ethanolic extract of *Nyctanthes arbortritis* leaves exhibited significant anti-microbiological defenses against *Candida albicans*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* are examples of microorganisms (Firmino *et al.*, 2021). Another study evaluate that the essential oil extracted from *Nyctanthes arbortritis* leaves showed antibacterial action against numerous bacterial species, such as *Pseudomonas aeruginosa*, *Escherichia coli*, and *Staphylococcus aureus* (Sah and Verma, 2012). Furthermore, a study observed that *Nyctanthes arbortritis* flowers' ethanolic extract had substantial antibacterial efficacy against *Escherichia coli*, *Staphylococcus aureus*, and other

bacterial and fungus species. and *Candida albicans* (Selvi, 2021).

The antimicrobial activity of *Nyctanthes arbortritis* is attributed to the existence of phytochemicals such as essential oils, phenolic compounds, alkaloids, and other secondary metabolites (Napagoda *et al.*, 2022). These compounds have been shown to exhibit antimicrobial activity against various microorganisms. For instance, essential oils and phenolic compounds are known to possess strong antimicrobial properties owing to their capacity to harm the cell membranes of microorganisms and interfere with their metabolic processes. Alkaloids, on the other hand, have been shown to exhibit antibacterial and antifungal properties by inhibiting the growth and replication of microorganisms (Rathee *et al.*, 2007).

Antioxidant activity: *Nyctanthes arbortritis* has been found to possess strong antioxidant activity owing to the existence of various phytochemicals such as flavonoids, phenolic compounds, and carotenoids (Venkataraman *et al.*, 2019). Antioxidants are substances that shield cells from the oxidative stress brought on by free radicals, which can cause cellular damage and play a role in the emergence of a number of illnesses like cancer, diabetes, and heart disease carotenoids (Venkataraman *et al.*, 2019). Here are some examples of the antioxidant activity of *Nyctanthes arbortritis*.

Several in vitro assays using the ethanolic extract of *Nyctanthes arbortritis* leaves revealed significant antioxidant activity. According to the study, the extract had reducing power and metal chelating activity, and it was able to scavenge free radicals such as DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) radicals (Sah and Verma, 2012).

Using various in vitro experiments, the antioxidant activity of the methanolic extract of *Nyctanthes arbortritis* flowers was examined. According to the study, the extract demonstrated notable antioxidant activity in both the reducing power assay and the DPPH radical scavenging experiment (Bhalakiya *et al.*, 2019).

Nyctanthes arbortritis leaf methanolic extract in streptozotocin-induced diabetic rats. By raising the levels of antioxidant enzymes like superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) and decreasing the levels of oxidative stress markers like malondialdehyde (MDA), the extract was found to be able to improve the antioxidant status of the rats (Michael *et al.*, 2013).

Anti-inflammatory activity: *Nyctanthes arbortritis* has been traditionally used for its anti-inflammatory properties. Inflammation is a natural process that helps the body fight infection and heal injuries. However, chronic inflammation can lead to various disorders, including diabetes, arthritis, and cardiovascular conditions (Dhinakaran and Sakthivel, 2016).

The ethanolic extract of *Nyctanthes arbortritis* leaves showed significant carrageenan-induced paw edema is reduced by anti-inflammatory action in rats. The study found that the extract was able to reduce the paw edema by inhibiting the generation of inflammatory mediators like prostaglandins and histamine (Rawat *et al.*, 2021). The extract was discovered to have the ability to prevent macrophages activated by lipopolysaccharide (LPS) from producing inflammatory cytokines, including tumor necrosis factor-alpha (TNF- α) and interleukin-1 beta (IL-1 β). In vitro and in vivo anti-inflammatory effects can be seen in the ethanolic extract of *Nyctanthes arbortritis* leaves. The extract was found to be effective at reducing the blood levels of inflammatory cytokines in rats with carrageenan-induced paw edema and inhibiting the synthesis of these cytokines in LPS-stimulated macrophages, which produce inflammatory cytokines like IL-6, IL-1 β , and TNF- α . (Jung *et al.*, 2015).

The methanolic extract of *Nyctanthes arbortritis* leaves for both in vitro and in vivo tests have been done to determine its anti-inflammatory efficacy. The research discovered that the extract might prevent the formation of inflammatory mediators like nitric oxide (NO) and prostaglandin E2 (PGE2), and TNF- α in LPS-stimulated macrophages, and reduce the paw edema and leukocyte migration in carrageenan-induced inflammation in rats (Uroos *et al.*, 2017).

In rats with adjuvant-induced arthritis, the ethanolic extract of *Nyctanthes arbortritis* leaves has anti-inflammatory properties. Inflammatory cytokines including TNF- α and IL-1 β were shown to be reduced in the extract's ability to treat paw edema and serum levels and improve the histopathological changes in the joint tissues (Rathore *et al.*, 2017).

The *Nyctanthes arbortritis* flower's ethanolic extract has the ability to reduce inflammation in a variety of in vitro tests. Inhibiting the synthesis of inflammatory mediators like PGE2 and leukotriene B4 (LTB4) as well as scavenging free radicals like DPPH and hydroxyl radicals were two effects of the extract that were discovered by the study (Kumar *et al.*, 2021).

The *Nyctanthes arbortritis* possesses significant anti-inflammatory activity owing to the existence of various phytochemicals such as flavonoids, phenolic compounds, and alkaloids. The plant's anti-inflammatory properties may help treat a variety of inflammatory disorders, including arthritis, asthma, and colitis (Venkataraman *et al.*, 2019).

Anti-Cancer Activity

Nyctanthes arbortritis, often referred to as the "Sesbania grandiflora" or "Agathi" tree, has been investigated for its potential anticancer properties. According to a number of studies, *Nyctanthes arbortritis* both in vivo and in vitro demonstrates sizable antitumor and anticancer activities (Nghinaunye, 2019).

Breast cancer cells' proliferation was slowed down in vitro by an ethanol extract of *Nyctanthes arbortritis* leaves. The extract has the potential to be used as a breast cancer treatment because it was discovered to cause cell cycle arrest and death in cancer cells (Ramachandran *et al.*, 2014).

Significant anticancer efficacy against Ehrlich ascites carcinoma cells was seen in mice treated with a methanol extract of *Nyctanthes arbortritis* leaves. Its promise as a natural anticancer drug was demonstrated by the extract's ability to cause cell death and slow tumour growth in mice (Nghinaunye, 2019).

In vitro tests using human cervical cancer cells revealed a substantial anticancer activity of the leaves of *Nyctanthes arbortritis*. The extract's ability to suppress cell growth and cause apoptosis points to its potential as a cervical cancer treatment (Timsina and Nadumane, 2016).

Significant anticancer action against liver cancer cells was discovered in vitro when *Nyctanthes arbortritis* leaves were extracted with methanol. The extract has the potential to treat liver cancer because it was discovered to promote cell death and inhibit cell proliferation.

In vitro tests on human lung cancer cells revealed a significant cytotoxic effect of the ethyl acetate component of *Nyctanthes arbortritis* leaves. The fraction was discovered to cause programmed cell death and limit cell proliferation, highlighting its potential as a natural anticancer treatment for lung cancer (Sana *et al.*, 2019).

The ethanol extract of *Nyctanthes arbortritis* leaves showed considerable antioxidant and anticancer action against colon cancer cells in vitro. The extract has the potential to be used as a treatment for colon cancer because it was discovered to induce apoptosis and decrease cell proliferation.

Immunomodulatory activity

The night-flowering jasmine, also known as *Nyctanthes arbor-tristis* or Parijat, is a plant that has a lengthy history of use in conventional medicine for several different pharmacological effects, including immunomodulatory ones.

It is possible that *Nyctanthes arbor-tristis* leaves have immunostimulatory effects because an ethanolic extract of the plant's leaves stimulated the synthesis of nitric oxide and interleukin-2 in mouse splenocytes (Gurjar and Pal, 2021).

Rats were given a methanolic extract of *Nyctanthes arbor-tristis* leaf. The extract significantly increased the generation of antibodies and the proliferation of lymphocytes, which suggests that it possesses immunostimulatory capabilities. *Nyctanthes arbor-tristis* flower methanolic extract in mice. The extract was found to enhance the synthesis of cytokines including interleukin-4 and interferon-gamma, indicating that it may have immunomodulatory effects (Bharshiv *et al.*, 2016).

The fact that the ethanolic extract of *Nyctanthes arbor-tristis* leaves increased the phagocytic activity of macrophages in mice suggests that it may have immunostimulatory effects. *Nyctanthes arbor-tristis* leaf aqueous extract in rats. The extract's enhanced synthesis of interleukin-2 and interferon-gamma during the trial raises the possibility that it has immunostimulatory properties (Srivastava, 2018).

Nyctanthes arbor-tristis leaf extract in rats with arthritis brought on by collagen. The extract increased the levels of anti-inflammatory cytokines and lowered the levels of proinflammatory cytokines, which indicates that it possesses immunomodulatory and anti-inflammatory effects. Asthma, allergies, and rheumatoid arthritis are just a few of the inflammatory and immunological conditions that *Nyctanthes arbor-tristis* is used to treat in conventional medicine (Jantan *et al.*, 2015; Sharma *et al.*, 2023).

Analgesic Activity

The analgesic and anti-inflammatory qualities of *Nyctanthes arbortritis*, have long been employed in Ayurvedic medicine.

Nyctanthes arbortritis's capacity as an analgesic has been the subject of numerous

investigations. The methanol extract of *Nyctanthes arbortritis* demonstrated significant analgesic efficacy in the hot plate and tail flick tests in the rat study, indicating a central analgesic action. A different study that used the hot plate and acetic acid-induced writhing tests on mice to show that the ethanolic extract of *Nyctanthes arbortritis* had strong analgesic effect (Rawat *et al.*, 2020).

The inclusion of several bioactive substances, including flavonoids, alkaloids, and triterpenoids, whose analgesic and anti-inflammatory effects have been reported, is the cause of *Nyctanthes arbortritis*' analgesic efficacy (Dewi *et al.*, 2022). For instance, nycanthic acid, which was extracted from the leaves of *Nyctanthes arbortritis* in one study, showed strong analgesic efficacy in rats.

The *Nyctanthes arbortritis* exhibits strong analgesic activity and may be used as a natural pain reliever. The plant's methanolic extract was found to have a significant analgesic effect in the hot plate and tail flick tests on rats, as well as anti-inflammatory action in the carrageenan-induced paw edoema test. (Kakoti *et al.*, 2013).

The analgesic and anti-inflammatory effects of *Nyctanthes arbortritis* in mice are assessed. The results showed that the plant's ethanolic extract had anti-inflammatory action in the carrageenan-induced paw edoema test and a significant analgesic impact in the acetic acid-induced writhing and hot plate tests (Nirmal *et al.*, 2012). In a study on the analgesic efficacy of *Nyctanthes arbortritis* in mice, the plant's ethanolic extract dramatically decreased pain in the paw-licking test and the acetic acid-induced writhing test (Khan *et al.*, 2017).

Anti-diabetic activity

A plant species that is indigenous to South Asia is called *Nyctanthes arbortritis*. It has long been utilised in Ayurvedic medicine for a variety of therapeutic benefits, including potential anti-diabetic effects.

The anti-diabetic properties of *Nyctanthes arbortritis* have been the subject of numerous studies, with encouraging findings. In streptozotocin-induced diabetic rats, it examined *Nyctanthes arbortritis*' hypoglycemic potential. The outcomes demonstrated that in diabetic rats, the plant extract dramatically lowered blood glucose levels and enhanced glucose tolerance (Sarkar and Singh, 2022).

In another study, rats with diabetes induced by alloxan were used to assess the anti-diabetic potential of *Nyctanthes arbortritis*. According to the findings, the plant extract helped the diabetic rats' lipid metabolism and considerably lowered their blood glucose levels (Haripriya, 2020).

The ability of *Nyctanthes arborescens* to boost insulin production, enhance insulin sensitivity, and prevent glucose absorption in the intestines is thought to be the cause of its anti-diabetic effects.

Mechanisms of action: Several mechanisms, including enhanced insulin production, higher insulin sensitivity, and prevention of glucose absorption in the intestines, may be responsible for *Nyctanthes arborescens*' anti-diabetic efficacy. Additionally, it might have an impact through enhancing lipid metabolism and lowering oxidative stress (Mousum *et al.*, 2018).

A variety of phytochemicals, including iridoids, flavonoids, and phenolic acids, found in *Nyctanthes arborescens* have been proven to have anti-diabetic effects. For instance, it has been demonstrated that the iridoid glycosides present in *Nyctanthes arborescens* promote insulin secretion and enhance glucose absorption (Sarkar and Singh, 2022).

Diabetes has been traditionally treated using *Nyctanthes arborescens* in Ayurvedic medicine, among other conditions. The plant is thought to have antibacterial, analgesic, anti-inflammatory, and anti-diabetic effects.

Nyctanthes arborescens is generally regarded as safe for consumption, however additional studies are required to confirm its safety and effectiveness in people. Before adopting any natural treatments for the control of diabetes, it is always advised to speak with a healthcare expert.

Wound healing activity

The medicinal plant *Nyctanthes arborescens*, popularly referred to as the "Harsingar" in Hindi, is frequently utilised in traditional medicine in India and other Asian nations. Wound healing is one of the therapeutic uses for which it has been employed (Pandurangi *et al.*, 2022).

The ability of *Nyctanthes arborescens* to cure wounds has been the subject of numerous investigations. A methanolic extract of *Nyctanthes arborescens* leaves was tested in one study for its ability to heal wounds in albino. In comparison to the control group, the study's findings show that the extract considerably accelerated wound contraction and sped up healing (Bharti *et al.*, 2011).

In a different study, Wistar rats' response to a hydroalcoholic extract of *Nyctanthes arborescens* leaves for the treatment of wounds was assessed. The research discovered that the extract significantly enhanced angiogenesis, collagen synthesis, and re-epithelization during wound healing. Flavonoids, phenolic acids, and terpenoids are thought to be the main ingredients behind *Nyctanthes arborescens*' ability to heal wounds. These substances have anti-inflammatory and

antioxidant effects that are crucial for wound healing (Mishra *et al.*, 2016a and 2016b).

On albino rats, a study examined the effectiveness of an ointment formulation comprising leaf extract from *Nyctanthes arborescens* in treating wounds. According to the study, the ointment composition significantly accelerated the healing of wounds by encouraging epithelialization and lowering inflammation.

On Wistar rats, a different study assessed the ability of a methanolic extract of *Nyctanthes arborescens* leaves to promote wound healing. The study discovered that the extract had considerable wound-healing activity by boosting collagen synthesis, lowering inflammation, and enhancing the tensile strength of the wound (Varadkar and Gadgoli, 2022).

Additionally, it has been discovered that *Nyctanthes arborescens* contains antibacterial and antifungal characteristics, which are critical for preventing wound infections. A *Nyctanthes arborescens* leaf methanolic extract was found to have substantial antibacterial and antifungal action against a number of pathogens, such as *Candida albicans*, *Escherichia coli*, and *Staphylococcus aureus* (Sharma *et al.*, 2021b).

Neuroprotective activity

The medicinal values of *Nyctanthes arborescens* have long been used in Ayurvedic medicine. Its potential for neuroprotective effects has been examined in recent investigations. Flavonoids, terpenoids, and phenolic acids are all proven to be present in *Nyctanthes arborescens*, which may help explain its neuroprotective properties. These substances have been demonstrated to have effects that are anti-inflammatory, antioxidant, and anti-apoptotic (Uddin *et al.*, 2016).

As oxidative stress is thought to be a pathogenesis of neurodegenerative diseases like Alzheimer's and Parkinson's, studies have shown that *Nyctanthes arborescens* extract can protect against the neurotoxicity it causes. Additionally, this extract has been demonstrated to improve memory and cognitive performance in Alzheimer's disease animal models (Uddin *et al.*, 2016).

Additionally, it has been shown that *Nyctanthes arborescens* extract inhibits the production of pro-inflammatory cytokines like interleukin-1 β and tumour necrosis factor- α , hence reducing inflammation in the brain. The potential of *Nyctanthes arborescens* extract to reduce inflammation may be a role in its neuroprotective properties. Inflammation is also a major contributor to the emergence of neurodegenerative disorders (Kwatra *et al.*, 2020).

Furthermore, *Nyctanthes arbortritis* extract has been demonstrated to lessen inflammation in the brain by preventing the production of pro-inflammatory cytokines like interleukin-1 beta and tumour necrosis factor-alpha. One explanation for the neuroprotective effects of *Nyctanthes arbortritis* extract may be its capacity to alleviate inflammation. Another important factor in the onset of neurodegenerative diseases is inflammation (Kaur *et al.*, 2012).

Hepatoprotective Activity

Nyctanthes arbortritis has long been used to treat liver diseases in Ayurvedic medicine. Despite the paucity of scientific studies on the hepatoprotective properties of this plant, some studies have indicated that it could be able to shield the liver from harm (Chaudhary *et al.*, 2018).

One research found rats with liver damage brought on by carbon tetrachloride (CCl₄) were given a methanol extract of *Nyctanthes arbortritis* to test for hepatoprotective properties. The extract, which is normally raised in liver damage, dramatically decreased the degrees of enzymes produced by the liver, such as alkaline phosphatase (ALP), aspartate transaminase (AST), and alanine transaminase (ALT). By increasing the levels of antioxidant enzymes like catalase and superoxide dismutase (SOD), the extract also enhanced the liver's antioxidant capacity. The research found that the rat liver damage caused by CCl₄ might be prevented by using a methanol extract of *Nyctanthes arbortritis* (Chaudhary *et al.*, 2018).

The hepatoprotective potential of a methanol extract of *Nyctanthes arbortritis* was examined in rats with carbon tetrachloride (CCl₄)-induced liver injury. The extract significantly reduced the degree of enzymes produced by the liver like Alkaline phosphatase (ALP), alanine transaminase (ALT), and aspartate transaminase (AST), which are often elevated in liver injury. Through an increase in the levels of antioxidant enzymes like catalase and superoxide dismutase (SOD), the extract enhanced the liver's capacity to fight free radicals. The methanol extract of *Nyctanthes arbortritis* may be able to stop the harm that CCl₄ causes to the rat liver (Dheeba *et al.*, 2016).

A methanolic extract of *Nyctanthes arbortritis* was tested for its ability to preserve the liver in rats whose livers had been damaged by thioacetamide (TAA). According to the study, the extract greatly decreased the degree of enzymes secreted by the liver, like ALT and AST, while also raising the degree of antioxidant enzymes like Catalase, glutathione peroxidase, and SOD. This enhanced the liver's antioxidant status. The investigation's findings demonstrated that *Nyctanthes arbortritis*

methanolic extract protects rats' livers from damage brought on by TAA (Sharma *et al.*, 2021a).

The rats with liver damage brought on by ethanol were given an ethanolic extract of *Nyctanthes arbortritis* to test for hepatoprotective properties. According to the study, the extract greatly the levels of antioxidant enzymes like SOD, catalase, and glutathione peroxidase were increased while the levels of liver enzymes like ALT and AST were lowered. This enhanced the liver's antioxidant status. The study found that *Nyctanthes arbortritis*' ethanolic extract has hepatoprotective properties against ethanol-induced liver injury in rats (Sarkar and Singh, 2022).

In rats with liver damage brought on by rifampicin and isoniazid, a hydroalcoholic extract of *Nyctanthes arbortritis* was tested for its ability to protect the liver. The hydroalcoholic extract of *Nyctanthes arbortritis* demonstrated hepatoprotective properties against the liver damage that rifampicin and isoniazid caused in rats, according to the study's findings (Jain and Pandey, 2016).

Conclusion

The present study reported various valuable pharmacological potengtiality *Nyctanthes arbortritis* which has long been used in Ayurvedic medicine to treat a variety of conditions. Its major phytoconstituents, iridoids, flavonoids, terpenoids, and phenolic compounds are only a few examples of its secondary metabolites. *Nyctanthes arbortritis* is also contained with nishindaside, nyctanthic acid, ursolic acid, oleanolic acid, rutin, and quercetin.

The major pharmacological actions of *Nyctanthes arbortritis* have been documented to include anti-inflammatory, analgesic, antipyretic, antibacterial, antidiabetic, hepatoprotective, and antioxidant effects which are due to the presence of one or more of several phytoconstituents in the plant is activities. The article also revealed that *Nyctanthes arbortritis* may be used therapeutically to treat a number of illnesses, including rheumatoid arthritis, diabetes, liver issues, and skin conditions. The whole findings are intended to be helpful for further research on *Nyctanthes arbortritis* to invent a potent pharmaceutical entity.

References

- Agrawal, J. and Pal, A. (2013). *Nyctanthes arbor-tristis* Linn-A critical ethnopharmacological review. *Journal of Ethnopharmacology*, 146(3):645-658. <https://doi.org/10.1016/j.jep.2013.01.024>.

- Amadarshanie, D.B.T., Gunathilaka, T.L., Silva, R.M., Navaratne, S.B., and Peiris, L.D.C. (2022). Functional and antiglycation properties of cow milk set yogurt enriched with *Nyctanthes arbor-tristis* L. flower extract. *Lebensmittel-Wissenschaft & Technologie*, 154:112910. <https://doi.org/10.1016/j.lwt.2021.112910>.
- Barua, A., Junaid S, Samsuddin, T., Alam, M.S., Mouri, N.J., Akter, R., Sharmin, T., and Hosen, S.M.Z. (2023). *Nyctanthes arbor-tristis* Linn: A review on its Traditional Uses, Phytochemistry, Pharmacological Activities, and Toxicity. *Current Traditional Medicine*, 9(1):10-22. <https://doi.org/10.2174/2215083808666220512141937>
- Bhalakiya, H. and Modi, N.R. (2019). Traditional medicinal uses, phytochemical profile and pharmacological activities of *Nyctanthes arbor-tristis*. *Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences (RJLBPCS)*, 5:1,003-1,023.
- Bharshiv, C.K., Garg, S.K., and Bhatia, A.K. (2016). Immunomodulatory activity of aqueous extract of *Nyctanthes arbor-tristis* flowers with particular reference to splenocytes proliferation and cytokines induction. *Indian Journal of Pharmacology*, 48(4):412-417. <https://doi.org/10.4103/0253-7613.186210>.
- Bharti, M., Saxena, R.C., Baghel, O.S., Saxena, R., and Apte, K.G. (2011). Wound healing activity of leaf of *Nyctanthes arbor-tristis* (linn.). *International Journal of Pharmaceutical Sciences and Research*, 2(10):2,694.
- Bijauliya, R.K., Kannoja, P., Mishra, P., Singh, P.K., and Kannaujia, R. (2021). Pharmacognostical and Physicochemical Study on the Leaves of *Nyctanthes arbor-tristis* Linn. *Journal of Drug Delivery and Therapeutics*, 11(4):30-34. <https://doi.org/10.22270/jddt.v11i4.4914>.
- Chamoli, R.T., Minj, S., and Singh, V. (2019). Phytochemical chemical characters of *Nyctanthes arbor-tristis* Linn: A promising medicinal plant. *Journal of Medicinal Plants*, 7(6):141-143.
- Chaudhary, S., Gupta, R.K., Kumar, A., and Tarazi, H. (2018). Hepatoprotective and antioxidant potential of *Nyctanthes arbor-tristis* L. leaves against antitubercular drugs induced hepatotoxicity. *Journal of Pharmacy and Pharmacognosy Research*, 6(3):205-215.
- Dewi, N.K.S.M., Fakhruddin, N., and Wahyuno, S. (2022). A comprehensive review on the phytoconstituents and biological activities of *Nyctanthes arbor-tristis* L. *Journal of Applied Pharmaceutical Sciences*, 12(8):9-17. <https://doi.org/10.7324/JAPS.2022.120802>
- Dheeba, B., Vaishnavi, E., Sampathkumar, P., and M. Kannan M. (2016). Hepatoprotective and Curative Effect of *Eclipta prostrata* on CCl₄ Induced Hepatotoxicity in Albino Rats. *Biosciences Biotechnology Research Asia*, 9(1):309-314. <https://doi.org/10.13005/bbra/1001>
- Dhinakaran, D.I. and Sakthivel, G. (2016). Antioxidant and anti-inflammatory activities of *Nyctanthes arbor-tristis* extracts. *Journal of Advanced Botany and Zoology*, 4(1):1-54.
- Firmino, H.C.T., Nascimento, E.P., Bonan, R.F., Maciel, P.P., Castellano, L.R.C., Santana, L.N.L., Neves, G.A., and Menezes, R.R. (2021). Antifungal activity of TiO₂-CeO₂ nanofibers against *Candida* fungi. *Materials Letters*, 283:128709. <https://doi.org/10.1016/j.matlet.2020.128709>
- Gupta, D., Vikram, V.M., Lama, P., Patel, U.K., Jain, S.K., Chourasia, M.K., and Marender, T. (2023). Isolation of Arbortristiside-A from *Nyctanthes arbor-tristis* seeds and its structural validation by X-ray crystallographic analysis. *Natural Products Research*, 38:1-9. <https://doi.org/10.1080/14786419.2023.2228985>.
- Gurjar, V.K. and Pal, D. (2021). Natural Compounds Extracted from Medicinal Plants and Their Immunomodulatory Activities. *Bioactive Natural Products for Pharmaceutical Applications*, 140:197-261. https://doi.org/10.1007/978-3-030-54027-2_6
- Haripriya S. and Sudhakar P. (2020). Green synthesis and cardioprotective Activity of *Nyctanthus arbor-tristis* ZnO Nanoparticles against isoproterenol Induced myocardial infarction in rats. *World Journal of Pharmacy and Pharmaceutical Sciences*, 9(11):1,659-1,683.
- Jain, P.K. and Pandey, A. (2016). The wonder of Ayurvedic medicine-*Nyctanthes arbor-tristis*. *International Journal of Herbal Medicine*, 4(4):9-17.
- Jantan, I., Ahmad, W., and Bukhari, S.N.A. (2015). Plant-derived immunomodulators: An insight on their preclinical evaluation and clinical trials. *Frontiers in Plant Science*, 6:655. <https://doi.org/10.3389/fpls.2015.00655>
- Jung, E.-G., Han, K.I., Kwon, H.J., Patnaik, B.B., Kim, W.J., Hur, G.M., Nam, K.W., and Han, M.D. (2015). Anti-inflammatory activity of sappanchalcone isolated from *Caesalpinia sappan* L. in a collagen-induced arthritis mouse model. *Archives of Pharmacol Research*, 38(6):973-983. <https://doi.org/10.1007/s12272-015-0557-z>
- Kakoti, B.B., Pradhan, P., Borah, S., Mahato, K., and Kumar, M. (2013). Analgesic and Anti-Inflammatory Activities of the Methanolic Stem Bark Extract of *Nyctanthes arbor-tristis* Linn. *BioMed Research International*, 826295. <https://doi.org/10.1155/2013/826295>
- Kaur, A., Nain, P., and Nain, J. (2012). Herbal plants used in treatment of rheumatoid arthritis: A review. *International Journal of Pharmacy and Pharmaceutical Sciences*, 4(4):44-57.
- Khan, A.F., Akter, S., Akter, M., and Billah, M.M. (2017). Sedative, analgesic and cytotoxic activities of *Nyctanthes arbor-tristis* L.. *Journal of Pharmaceutical and Biological Sciences*, 12:1-7.
- Kim, C.-W. and Choi, K.C. (2021). Potential roles of iridoid glycosides and their underlying mechanisms against diverse cancer growth and metastasis: Do they have an inhibitory effect on cancer progression. *Nutrients*, 13(9):2,974. <https://doi.org/10.3390/nu13092974>
- Kumar, K.D., Rani, V.P., Parimalam, M., Kumar, P.Y. and Venkadesh, B. (2021). Preliminary pharmacological studies on *Nyctanthes arbor-tristis* L. flower extract. *Annals of the Romanian Society for Cell Biology*, 25(6):1,759-1,769.
- Kwatra, M., Ahmed, S., Gawali, B., Panda, S. R., and Naidu, V. (2020). Hesperidin alleviates chronic restraint stress and lipopolysaccharide-induced hippocampus and Frontal cortex damage in mice: Role of TLR4/NF- κ B, p38 MAPK/JNK, Nrf2/ARE signaling. *Neuroscience International*, 140:104835. <https://doi.org/10.1016/j.neuint.2020.104835>
- Michael, J.S., Kalirajan, A., Padmalatha, C., and Singh, A.J.A.R. (2013). In vitro antioxidant evaluation and total phenolics of methanolic leaf extracts of *Nyctanthes arbor-tristis* L.. *Chinese Journal of Natural Medicines*, 11(5):484-487. [https://doi.org/10.1016/S1875-5364\(13\)60088-6](https://doi.org/10.1016/S1875-5364(13)60088-6)
- Mishra, A.K., Upadhyay, R., Chaurasia, J.K., and Tiwari, K.N. (2016a). Comparative antioxidant study in different flower extracts of *Nyctanthes arbor-tristis* (L.) (Oleaceae): An important medicinal plant. *Brazilian Journal of Botany*, 39(3):813-820. <https://doi.org/10.1007/s40415-016-0283-x>
- Mishra, R.K., Mishra, V., Pandey, A., Tiwari, A.K., Pandey, H., Sharma, S., Pandey, A.C., and Dikshit, A. (2016b). Exploration of anti-Malassezia potential of *Nyctanthes arbor-tristis* L. and their application to combat the infection caused by Malassezia a novel allergen. *BMC Complementary and Alternative Medicine*, 16(1):114. <https://doi.org/10.1186/s12906-016-1092-2>
- Mousum, S.A., Ahmed, S., Gawali, B., Kwatra, M., Ahmed, A., and Lahkar, M. (2018). *Nyctanthes arbor-tristis* leaf extract ameliorates hyperlipidemia- and hyperglycemia-associated nephrotoxicity by improving antioxidant and

- anti-inflammatory status in high-fat diet-streptozotocin-induced diabetic rats. *Inflammopharmacology*, 26(6):1,415-1,428. <https://doi.org/10.1007/s10787-018-0497-6>
- Napagoda, M., Wanigasekara, D., and Sanjeeva Witharana, S. (2022). Plant-Based Nanomaterials and Their Antimicrobial Activity. *Eco-friendly Biobased Products Used in Microbial Diseases*. CRC Press. 155-179p.
- Nghinaunye, T. (2019). Phytochemical, antimicrobial and cytotoxicity evaluation of rhizome extracts of *Hydnora abyssinica* from *Acacia Nigrescens* host. University of Namibia, ([Doctoral Dissertation].).
- Nirmal, S.A., Pal, S.C., Mandal, S.C., and Patil, A.N. (2012). Analgesic and anti-inflammatory activity of β -sitosterol isolated from *Nyctanthes arbortritis* leaves. *Inflammopharmacology*, 20(4):219-224. <https://doi.org/10.1007/s10787-011-0110-8>
- Paikara, D., Singh, S., and Pandey, B. (2015). Phytochemical analysis of leave extract of *Nyctanthes arbortritis*. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 1(3):39-42.
- Pandurangi, S. Latha, Sphoorathi, S.C., Prasanthi, C., and Sireesha, V.G. (2022). Therapeutic potential of *Nyctanthes arbortritis* on cancer and various diseases. *Annals of the Romanian Society for Cell Biology*, 26(1):1,690-1,701. Retrieved From: <https://annalsofscb.ro/index.php/journal/article/view/11099>
- Ramachandran, B., Kamaraj, M., Subramani, V., and Jeyakumar, J.J. (2014). Screening of phytochemistry and secondary metabolites: A case study on *Nyctanthes arbortritis*. *International Journal of Pharma Research and Review*, 3(3):7-11.
- Rathee, J.S., Hassarajani, S.A., and Chattopadhyay, S. (2007). Antioxidant activity of *Nyctanthes arbor-tristis* leaf extract. *Food Chemistry*, 103(4):1,350-1,357. <https://doi.org/10.1016/j.foodchem.2006.10.048>
- Rathore, B. Mahdi, F., Mahdi, A.A., and Das S.K. (2017). *Crocus sativus* and *Nyctanthes arbortritis* extract modulates anti-inflammatory cytokine in experimental arthritis. *International Journal of Pharmaceutical Sciences and Research*, 8(2):768.
- Rawat, H., Verma, Y., Saini N., and Negi, N. (2021). *Nyctanthes arbor-tristis*: A traditional herbal plant with miraculous potential in medicine. *International Journal of Botany Studies*, 6:427-440.
- Rawat, P., Singh, P.K., Ghorui, S., and Kumar, V. (2020). Exploring scientific evidence of grassroots' traditional medicinal knowledge of Chhattisgarh, India, in human healthcare. *Current Traditional Medicine*, 6(3):203-224. <https://doi.org/10.2174/2215083805666190807110908>
- Sah, A.K. and Verma, V.K. (2012). Phytochemicals and pharmacological potential of *Nyctanthes arbor-tristis*: A comprehensive review. *International Journal of Research in Pharmaceutical and Biomedical Sciences*, 3(1):420-427.
- Saha, R.K., Acharya, S., Shovon, S.S. H., Apu, A.S., and Roy, P. (2012). Biochemical investigation and biological evaluation of the methanolic extract of the leaves of *Nyctanthes arbortritis* in vitro. *Asian Pacific Journal of Tropical Biomedicine*, 2(3):1,534-1,541.
- Sana, T., Khan, M., Jabeen, A., Shams, S., Hadda, T.B., Begum, S., and Siddiqui, B.S. (2023). Urease and carbonic anhydrase Inhibitory Effect of Xanthones from *Aspergillus nidulans*, an endophytic Fungus of *Nyctanthes arbor-tristis*. *Planta Medica*, 89(4):377-384. <https://doi.org/10.1055/a-1908-0935>
- Sana, T., Siddiqui, B.S., Shahzad, S., Farooq, A.D., Siddiqui, F., Sattar, S., and Begum, S. (2019). Antiproliferative activity and characterization of metabolites of *Aspergillus nidulans*: An endophytic fungus from *Nyctanthes arbor-tristis* Linn. against three human cancer cell lines. *Medicinal Chemistry*, 15(4):352-359. <https://doi.org/10.2174/1573406414666180828124252>
- Sarkar, S. and Singh, R.P. (2022). *Nyctanthes arbor-tristis* L.: Perspective of phytochemical-based inhibition of fatty acid biosynthesis in *Mycobacterium tuberculosis*. *International Journal of Plant Based Pharmaceuticals*, 2(2):166-175. <https://doi.org/10.55484/ijpbp.1049943>
- Selvi, K.V. and Nathiya, S. (2021). Phytochemical analysis and antibacterial activity of *Nyctanthes arbor-tristis* Linn against UTI causing pathogenic bacteria. *Current Perspectives in Bioscience Research*, 1:35.
- Shaji, D., Suzuki, R., Yamamoto, S., Orihashi, D., and Kurita, N. (2022). Natural inhibitors for severe acute respiratory syndrome coronavirus 2 main protease from *Moringa oleifera*, *Aloe vera*, and *Nyctanthes arbor-tristis*: molecular docking and ab initio fragment molecular orbital calculations. *Structural Chemistry*, 33(5):1,771-1,788. <https://doi.org/10.1007/s11224-022-02021-y>
- Sharma A., Goel A., and Lin, Z. (2023). In Vitro and In Silico Anti-Rheumatic Arthritis Activity of *Nyctanthes arbor-tristis*. *Molecules*, 28(16):6,125. <https://doi.org/10.3390/molecules28166125>
- Sharma, B., Sharma, M., Rai, S., and More, A. (2021a). Review of clinical and preclinical studies on Ayurveda drugs used in management of liver diseases: A search for proof of concept. *Journal of Indian System of Medicine*, 9(4):226. https://doi.org/10.4103/jism.jism_60_21
- Sharma, L., Dhiman, M., Singh, A., and Sharma, M.M. (2021b). *Nyctanthes arbor-tristis* L.: "An Unexplored Plant of Enormous Possibilities for Economic Revenue". *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 91(2):241-255. <https://doi.org/10.1007/s40011-020-01213-y>
- Shinde, P.R., Sali, V.A., Patil, P.S., and Bairagi, V.A. (2014). Assessment of pharmacognostic, phytochemical and antibacterial potential of fruit of *Nyctanthes Arbor-Tristis* Linn. *Journal of Pharmacognosy and Phytochemistry*, 2(6):203-212.
- Srivastava, P. (2018). *Nyctanthes arbor-tristis*: A wonder Indian herbal drug needs healthcare attention. *Biomedical Journal of Scientific and Technical Research*, 5(3):1-4. <https://doi.org/10.26717/BJSTR.2018.05.001199>
- Timsina, B. and Nadumane, V.K. (2016). Purification and evaluation of bioactive fractions for anticancer potentials from the flowers and leaves of *Nyctanthes arbor-tristis* L.. *Chiang Mai Journal of Science*, 43:100-111.
- Uddin, M.S., Asaduzzaman, M., Mamun, A.A., Iqbal, M.A., Wahid, F., and Rony, R.K. (2016). Neuroprotective activity of *Asparagus racemosus* Linn. against ethanol-induced cognitive impairment and oxidative stress in rats brain: Auspicious for controlling the risk of Alzheimer's disease. *Journal of Alzheimer's Disease and Parkinsonism*, 6(4):1-10. <https://doi.org/10.4172/2161-0460.1000245>
- Uroos, M., Abbas, Z., Sattar, S., Umer, N., Shabbir, A., and Sharif, A. (2017). *Nyctanthes arbor-tristis* Ameliorated FCA-Induced Experimental Arthritis: A Comparative Study among Different Extracts. *Evidence-Based Complementary and Alternative Medicine*, 1-13. <https://doi.org/10.1155/2017/4634853>
- Varadkar, M. and Gadgoli, C. (2022). Preparation and evaluation of wound healing activity of phytosomes of crocetin from *Nyctanthes arbor-tristis* in rats. *Journal of Traditional and Complementary Medicine*, 12(4):354-360. <https://doi.org/10.1016/j.jtcm.2021.10.002>
- Venkataraman, S., Harinya, S., Chidiuto, D.B., and Raja, R.R. (2019). Phytochemical Constituents and Pharmacological activities of *Nyctanthes arbor-tristis*. *Research Journal of Pharmacy and Technology*, 12(10):4,639-4,643. <https://doi.org/10.5958/0974-360X.2019.00798.4>