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Pushpendra Kumar Jain
Dean & H.O.D. Pharmacy,
Naraina Vidya Peeth Group of
Institutions, Panki-Kanpur,
Uttar Pradesh, India

Arti Pandey
Research Scholar, Naraina Vidya
Peeth Group of Institutions,
Panki-Kanpur, Uttar Pradesh,
India

The wonder of Ayurvedic medicine - *Nyctanthes arbortristis*

Pushpendra Kumar Jain, Arti Pandey

Abstract

Nyctanthes arbortristis (N. Arbortristis) is one of the most useful traditional medicinal plants in India. It is distributed widely in sub-Himalayan regions and Southwards to Godavari. Each part of the plant has some important medicinal value and is thus commercially exploitable. It is now considered as a valuable source of several unique products for the medicines against various diseases and also for the development of some industrial products. The present review is to focus on the potential phyto-chemicals and pharmacological activity of plant N. Arbortristis. Various parts of the plant like seeds, leaves, flowers, bark and fruits have been investigated for their significant pharmacological activity. Phyto-chemicals like flavanoid, glycoside, oleanic acid, essential oils, tannic acid, carotene, friedeline, lupeol, glucose, benzoic acid have been reported for significant hair tonic, hepatoprotective, anti-leishmaniasis, anti-viral, anti-fungal, anti-pyretic, anti-histaminic, anti-malarial, anti-bacterial, anti-inflammatory and anti-oxidant activities of Night jasmine and emphasizes the need for further exploring available information.

Keywords: *Nyctanthes arbor-tristis*, N. Arbortristis, anti-inflammatory, anti-bacterial, hepatoprotective, anti-microbial, Harsingar, Night jasmine

1. Introduction

Nyctanthes arbortristis (N. arbortristis) is a valuable medicinal plant which belongs to the family Oleaceae. The plant generally grows in tropical and subtropical region. N. arbortristis commonly known as Night jasmine, Harsinghar & Parijat. The flowers start falling after midnight and by the day break, the plant appears dull. The generic name 'Nyctanthes' has been coined from two Greek words 'Nykhta' (Night) and 'anthos' (flower) ^[1, 2]. It is usually a shrub or a small tree having brilliant, highly fragrant flowers, which bloom at night and fall off before sunrise, giving the ground underneath a pleasing blend of white and red. Thus, during the day the plant loses all its brightness and hence is called "Tree of sadness" (arbor-tristis). It is also known as Harsinghar, Coral Jasmine, Parijat, queen of the night and night flowering jasmine ^[3]. It is a *Nyctanthes arbortristis* of India, distributed in sub-Himalayan region and also found in Indian garden as ornamental plant.

The plant is tolerant to moderate shade and can grow on rocky ground in dry hill shades, dry deciduous forests or at sea-level up to 1500 m altitude with a wide range of rainfall patterns, from seasonal to non seasonal and is tolerant to moderate shade. It is often cultivated in gardens due to its most pleasant and peculiar fragrance ^[4, 5]. In India, it grows in the outer Himalayas and is found in tracts of Jammu and Kashmir, Nepal to East of Assam, Bengal, Tripura extended through the Central region up to Godavari in the South. Flowering usually occurs from July to October. N. arbortristis prefers a secluded and semi-shady place to grow ^[6]. N. arbortristis is one of the well known medicinal plant. It is a common wild hardy large shrub or small tree. Different parts of this plant are used in Indian systems of medicine for various pharmacological actions like as anti-leishmaniasis, anti-viral, anti-fungal, anti-pyretic, anti-histaminic, anti-malarial, anti-oxidant ^[7], anti-inflammatory ^[8] and many more activities.

Herbs have been always the main principle form of medicine since traditions in India and now a day it becomes most popular throughout the world. Important large shrub of tropical and subtropical regions of the world that has been traditionally used to provoke menstruation, for treatment of scabies and other skin infections as hair tonic ^[9], chalogogue and Herbal medicines are not only providing traditional and ethnic medicine but also promising for highly efficient novel bioactive molecules. Since ages, man has been dependent on N. arbortristis for curing various body diseases. From ancient civilization various parts of different plants were used to pain, control suffering and counteract disease. Most of the drugs used in primitive medicine

Correspondence

Pushpendra Kumar Jain
Dean & H.O.D. Pharmacy,
Naraina Vidya Peeth Group of
Institutions, Panki-Kanpur,
Uttar Pradesh, India

were obtained from plants and are the earliest and principle N. arbortristis source of medicines.

2. Plant Description

This tree grows well in a wide variety of loamy soils and in soils found in average garden situations, with pH 5.6–7.5. The plant requires conditions varying from full sunlight to partial shade and needs to be watered regularly, but does not require over watering. [3] It is a terrestrial woody perennial having life span of 5 - 20 years.

3. Classification of Plant

Class	:	Eudicots
Division	:	Angiosperm
Family	:	Oleaceae
Genus	:	Nyctanthes
Kingdom	:	Plantae
Order	:	Lamiales
Species	:	<i>Nyctanthes arbortristis</i>

4. The plant is named in different Vernacular languages as below

Bengali:	Harsinghar, Sephalika, Seoli, Sheoli.
English:	Coral Jasmine, Night Jasmine.
Filipino:	Coral Jasmine.
Gujarati:	Jayaparvati, Parijatak.
Hindi:	Harsinghar, Harsingur, Seoli, Sheoli, Sihau.
Indonesian:	Srigading (Sundanese, Javanese).
Kannada:	Goli, Harsing, Parijata.
Konkani:	Pardic, Parizatak, Parzonto, Parzot.
Lao (Tibetan):	Salikaa.
Malay:	Seri Gading.
Malayalam:	Mannapu, Pavizhamalli, Parijatakam.
Marathi:	Kharbadi, Kharassi, Khurasli, Parijatak.
Oriya:	Godokodiko, Gunjoseyoli, Singaraharo.
Punjabi:	Harsinghar.
Sanskrit:	Parijata, Parijatah, Parijataka, Sephalika.
Tamil:	Manjhapu, Pavala-Malligai, Pavazha-Malligai.
Telugu:	Kapilanagadustu, Pagadamalle, Parijat, Sepali.
Thai:	Karanikaa.
Urdu:	Gulejafari, Harsingar.
Vietnamese:	Iai Tau.

5. Characteristic Features of *Nyctanthes arbortristis*

N. arbortristis is a deciduous tree grows up to 10 m tall, with quadrangular branches and grey or greenish-white rough bark [10] (Fig.1). The leaves are rough, hairy, decussately opposite, and simple. The flowers are arranged at the tips of branches. It grows well in loamy soils. The plant requires conditions varying from full sunlight to partial shade and needs to be watered regularly Flowering usually occurs from July to October. The whole plant is of medicinally useful.

5.1 Leaves: Leaves are opposite, 5 -10 by 2.5 – 6.3 cm, ovate, acute or acuminate, entire or with a few large distant teeth, short bulbous hairs rounded or slightcuneate, main nerves few, conspicuous beneath, petiol 6cm long, hairy. Leaves are simple, petiolate and exstipulate [11]. The lamina is ovate with acute or acuminate apex, the margin entire or serrated, somewhat undulated, particularly near the base, the upper surface dark green with dotted glands, and the lower surface pale green and softly pubescent. *N. arbortristis* venation is unicostate, reticulate with an average of 12 lateral veins leaving the midrib. The petioles are about 5–7.7–10 mm long with adaxial concavity [12]. (Fig.1)

5.2 Seeds: The seed is compressed and is 1 per cell. Seeds are exalbuminous, testa thick, the outer layer of large transparent cells and heavily vascularised [11, 13]. (Fig.1)

5.3 Flowers: The flowers are arranged at the tips of branches terminally or in the axils of leaves and are small, often seen in clusters of 2-7 together [9], delightfully fragrant, sessile in pedunculate bracteate fascicles of 3–5, peduncles 4-angled, slender, hairy, auxiliary and solitary and in terminal short trichotomous chymes, bracts broadly ovate or suborbicular, 6-10 mm long, apiculate, hairy on both sides, Calyx 6-8 mm long, narrowly campanulate, hairy outside, glabrous inside, truncate or obscurely toothed or lobed, ciliated. Corolla glabrous rather more than 13 mm long, tube 6-8 mm long, orange colour, about equalling the limb, lobes white corolla with an orange-red center and sessile with campanulate calyx, unequally obcordate, cuneate [11, 13]. (Fig.1)

5.4 Fruits: Fruits of *N. Arbortristis* are acapsule of 1-2 cm diameter, long and broad, obcordate orbicular, compressed, 2-celled, separating into 2 flat 1-seeded carpels, reticularly veined, glabrous. [11, 12] Macroscopic character of fruit: the fruit is flat, brown and heart cordate-shaped to rounded-capsule, around 2 cm in diameter with two celled opening transversely from the apex, each containing a single seed. Microscopically fruit showed typical character of fruit. In the epicarp epidermal cells were compactly arranged, polygonal cells with slightly anticlinal walls covered by a thin cuticle followed by 1-3 layers of collenchyma, Spongy Parenchymatous tissue, sclerenchymatous fibres and oil gland [13, 14]. (Fig.1)

5.5 Stem & Bark: It is large shrub growing up to 10 m tall, with quadrangular branches. Bark of *N. arbortristis* plant is dark gray or brown in colour and rough and firm. Bark surface is dippled due to scaling off of circular barks and patchy due to gray brown colour regions. Scaling off the bark by circular flakes. Inner bark is creamy white, soft and collapsed and non-collapsed phloem zone distinctly visible. [12] (Fig.1)

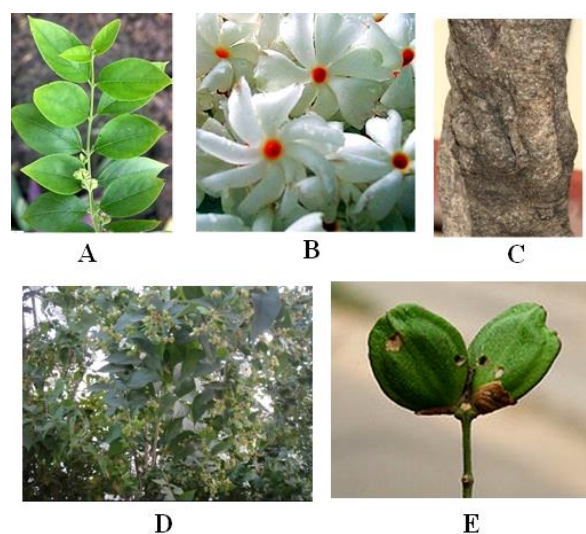


Fig 1: (A) Leaves, (B) Flowers, (C) Bark, (D) Whole Plant, (E) Fruits & Seeds.

6. Chemical Constituents

A variety of constituents belonging to different chemical classes such as terpenes, steroids, glycosides, flavonoids [15], alkaloids and aliphatic compounds have been isolated and

characterized from different parts of *N. arbortristis*. The secondary metabolites such as glycosides and alkaloids are the largest groups of chemicals produced by this plant [16]. The glycosides are iridoid glycosides and phenylpropanoid glycosides [17, 18]. Iridoid glucosides, arbortristoside A, B, D and E (Fig.2) have been isolated from the seed [19]. These possess immunomodulatory and anti-leishmanial activities.

6.1. Phyto-constituents From Leaves: Leaves contain mannitol, astringent, resinous substances, ascorbic acid, coloring matters, sugar and traces of an oily substance, tannic acid, methyl salicylate, carotene, an amorphous resin and traces of volatile oil. Seed kernels yield 12-16% of the pale yellow brown fixed oil, which consists of glucosides of linoleic, oleic, lignoceric, stearic, palmitic acid and β -sitosterol [20, 21]. Three new benzoic esters of Loganin and 6- β -hydroxyloganin, namely arborside-A, arborside-B, and arborside-C were found to be present in the leaves. Leaves also contain the alkaloid nyctanthine along with nannitol, β -Amyrin β -Sitosterol, hentriacontane, benzoic acid, astragaline, nicotiflorin, oleanolic acid, nyctanthic acid, friedelin and lupeol [22]. (Table.1)

6.2. Phyto-constituents From Stems: A glycoside Naringenin-4'-O- β -glucopyranosyl- α -xylopyranoside was screened from the stem chromatographed the chloroform extract of the stem over silica gel column and reported the presence of β -Amyrin, arbortristoside-a, oleanolic acid, nyctoside-a, nyctanthic acid and 6- β -hydroxyloganin [22]. (Table.1)

6.3. Phyto-constituents From Seeds: Seeds give a water

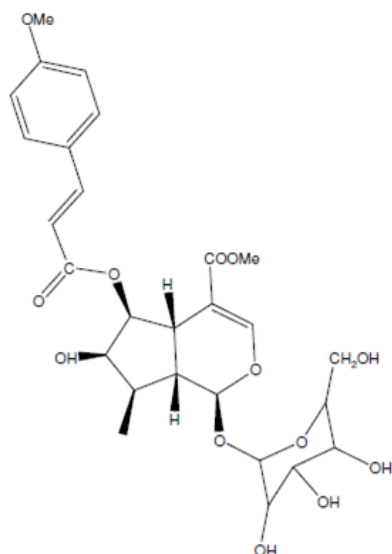
soluble polysaccharide containing D-Glucose and D-Mannose, indicating that the polysaccharide is a glucomannan. Iridoidglucosides arbortristoside-A, arbortristoside B, arbortristoside-C (Fig.2) and 6- β -hydroxyloganin. Further *N. Arbortristis* also contains two minor iridoidglucosides, arbortristoside-D and arbortristoside-E together with the previously reported arbortristoside-B. Other iridoid glucoside reported are as phenyl propanoid glucoside [22]. (Table .1)

6.4. Phyto-constituents From Flowers: Flowers contain modified diterpenoid nyctanthin, flavonoids, anthocyanins and an essential oil which is similar to that of jasmine [17]. The orange tubular calyx of the flower contains carotenoids [8]. It also contain an antiplasmodial cyclohexylethanoid, renygolone, a new iridoidglucoside 6-O -trans-cinnamoyl-7-O-acetyl-6- β -hydroxyloganin and three known iridoidglucosides, arborside-C, 6- β -hydroxyloganin (Fig.2) and nyctanthoside. Rengyolone was first isolated from *Forsythia suspansa* (Oleaceae), an important plant of the crude drug "rengyo". It was also reported that Halleridone from the African medicinal plant *Hallerialucida* (Scrophulariaceae) and as a cytotoxic constituent from *Cornus controversa* (cornaceae). It was found that after several months the compound arborside-C has changed to the isomeric structure with the benzoate group shifted to C-6-OH. This structure is named as isoarborside-C [22]. (Table .1)

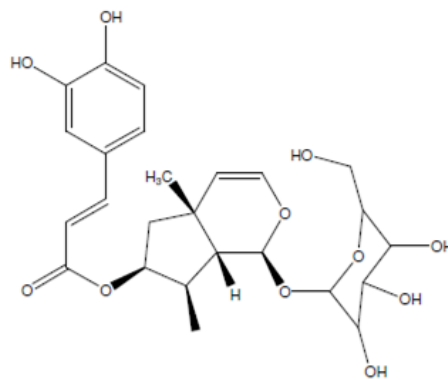
6.5 Phyto-constituents From Roots: The root part of the plant composed of alkaloids, tannins and glucosides. From the chloroform extract of the root β -Sitosterol and oleanolic acid has been isolated [19].

Table 1: Phyto-constituents present in various parts of plant [23].

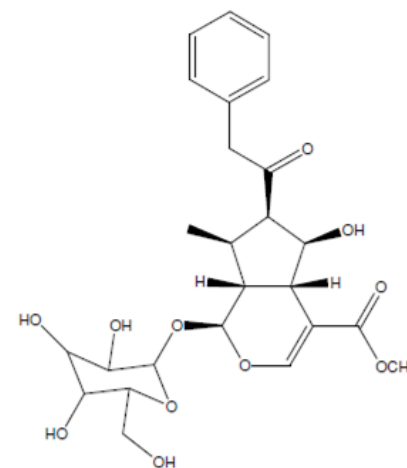
Plant parts	Phyto-constituents
Bark	Alkaloids, Glycosides.
Flower oil	Anisaldehyde, Phenyl acetaldehyde, p-cymene, 1-deconol, 1- hexanol methyl heptanone, α -pinene.
Flowers	Apigenin, Anthocyanin, D-Mannitol, Tanninm, Glucose, Carotenoid, Essential Oil, Kaemferol, Nyctanthin, Glycosides, Quercetin, Rengylone, α -crocetin (or crocin-3), β -monogentiobioside, β -monogentiobioside- β -D, β -digentiobioside.
Leaves	Ascorbic Acid, Benzoic Acid, Carotene, D-Mannitol, Flavanol Glycosides-Astragaline, Friedeline, Fructose, Glucose, Iridoid Glycosides, Lupeol, Mannitol, Methyl Salicylate, Nicotiflorin, Nyctanthic Acid, Oleanolic Acid, Tannic Acid, β -Sitosterole.
Seeds	3-4 Secotriterpene Acid, a Pale Yellow Brown Oil (15%), Arbortristoside A & B, Glycerides of Linoleic Oleic, Lignoceric, Myristic Acids, Nyctanthic Acid, Palmitic, Stearic.
Stem	Glycoside-naringenin-4'-O- β -glucapyranosyl- α -Xylopyranoside, β -sitosterol.



Arbortristoside A



Arbortristoside B



Arbortristoside C

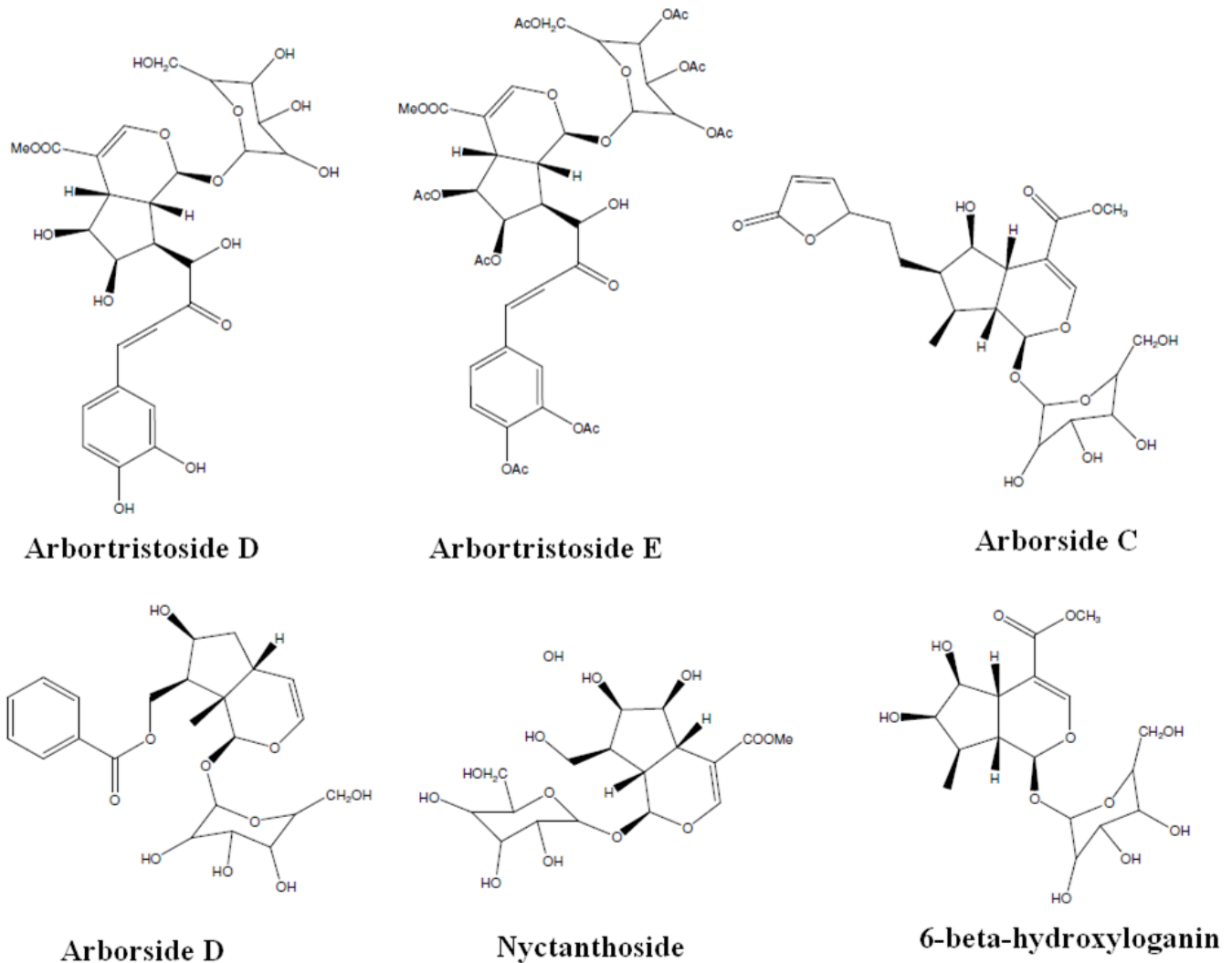


Fig 2: Phyto-constituents from *Nyctanthes arbortristis*

7. Physico-chemical properties of *Nyctanthes arbortristis* leaves

Physico-chemical properties (Table.2) of *N. arbortristis* leaves fat were determined to be 2.10%. The leaves were of dark green colour. It is a viscous semi solid substance at room temperature. Acid value of *N. arbortristis* leaves were found to be 76.27. High acid value indicates that this oil is inedible. The iodine values of *N. arbortristis* leaves were found to be 134.44. The result indicates that *N. arbortristis* leaves are highly unsaturated. The *N. arbortristis* leaves contained (Table 2) moisture 50.01%, ash 13.98%, lignin 15.87%, crude fiber 9.41%, fat 2.10%, protein 15.02% and carbohydrate 9.48% [24].

Table 2: Physico-chemical properties of *Nyctanthes arbortristis* leaves [24].

S. No	Chemical components	Result
1	Colour	Dark green
2	Appearance	Viscous semi solid substance
3	Moisture	50.01%
4	Ash	13.98%
5	Lignin	15.87%
6	Crude fibre	9.41%
7	Fat	2.10%
8	Protein	15.02%
9	Carbohydrate	9.48%
10	Acid value	76.27
11	Iodine value	134.44

8. Qualitative analysis of Phyto-constituents in *Nyctanthes arbortristis*

The phyto-constituents analysis revealed the presence of secondary metabolites such as tannins, saponins, alkaloids, flavanoids, steroids, phenolic compounds, reducing sugar and carbohydrate in *N. arbortristis* (Table.3) [25].

Table 3: Phyto-constituents present in aqueous extract of *N. arbortristis* [25].

S. No	Phyto-Constituents	Results
1	Alkaloid	+
2	Anthraquinone Glycosides	-
3	Carbohydrates	
	Moliseh's test	+
	Benedict's test	+
4	Fehling's test	+
	Cardiac Glycoside	+
5	Flavanoid	+
6	Phenol	+
7	Proteins and amino acids	
	Biuret test	+
8	Reducing sugar	+
9	Saponin	+
10	Steroid	+
11	Tannin	+
12	Terpenoids	+
+ Present / - Absent		

9. Medicinal Uses of *Nyctanthes arbortristis*

Some of the medicinal attributes of various parts of plant have been summarized in (Table.4). However apart from these uses, there are several reports on pharmacological actions of *N. arbortristis* [43].

Table 4: Pharmacological Activity shown by Different Parts of *N. arbortristis* [43].

Part Used	Pharmacological Effect
Bark	Anti-Microbial
Flower Oil	Perfume
Flowers	Ant-Bilious Antifilarial Anti-Inflammatory Antioxidant Diuretic Dyspepsia Ophthalmic Sedative
Leaves	Anthelmintic Antibacterial Antifungal Anti-Inflammatory Antioxidant Anti-Pyretic Arthritis Asthma Bronchitis Cholecystagogue Constipation Cough Dyspepsia Flatulence Heartburn Hepatoprotective Immunopotential Nausea Reptile Venom Rheumatism Ringworm Sciatica
Seeds	Antibacterial Antifungal Alopecia Antileishmanial Hair Tonic Immunomodulatory Piles
Stem	Antioxidant Antipyretic Bronchitis Snakebite

9.1 Anti-Allergy Activity

The pretreatment of guinea pigs exposed to histamine aerosol with a water soluble portion of the alcoholic extract of *N. arbortristis* leaves offered significant protection against the development of asphyxia. Arbortristiside A and arbortristiside C are present in *N. arbortristis* were reported to be anti-allergic [26].

9.2 Anti Anxiety

Hydroalcoholic extracts of *N. Arbortristis* (NAT) have anxiolytic potential. Using hydro-alcoholic mixture, dried plant parts of *N. Arbortristis* was extracted, concentrated by distilling off the solvent and then evaporated to dryness on the water bath and then stored in an air tight container in a refrigerator till used [27].

9.3 Anti-Inflammatory activity

The aqueous extract of the whole plant, alcoholic extract of stem and seeds and water soluble portion of the alcoholic extract of leaves of *N. arbortristis* were reported to have acute and sub-acute anti-inflammatory activity. The acute anti-inflammatory activity is evaluated on inflammatory models using different phlogistic agents' viz. carrageenan, formalin, histamine, 5-hydroxytryptamine and hyaluronidase in the hind paw of rats. In the sub-acute models, *N. arbortristis* was found to check granulation tissue formation significantly in the granulomapouch and cotton pellet test. *N. arbortristis* is also found to inhibit the inflammation produced by immunological methods that are Freund's adjuvant arthritis and purified tuberculin reaction [28].

9.4 Anti-Aggressive Activity

The fresh juice obtained from the leaves of the plant was found to have anti malarial activity. The 50% ethanolic extract of the seeds, leaves, roots, flowers and stem of the plant has been proved to possess antiamebic and anti allergic properties. Leaf extract of the plant showed antiinflammatory, analgesic, antipyretic and ulcerogenic activities. The leaves, seeds and flowers of the plant were reported to exert immunostimulant activity. The water soluble fraction of the ethanolic extract has been proved to possess tranquilizing, antihistaminic, purgative effects and depletion of tumor necrosis. The arbortristiside A isolated from the seeds was found to have antitumor activity [29].

9.5 Anti-Filarial activity

The chloroform extract of the flowers and a pure compound isolated from *N. arbortristis* plant exhibit larvicidal activity against *Culex quinquefasciatus*, a common filarial vector [30].

9.6 Anti-Bacterial activity

Infectious diseases are world's leading cause of premature death. Resistance to antimicrobial agents is conferring in a wide variety of pathogens and multiple drug resistance is becoming common in diverse organisms such as *Staphylococcus aureus*, *Staphylococcus epidermis*, *Salmonella typhi*, *Salmonella paratyphi A*. In a study, it was reported that methanolic extract of leaves of *N. arbortristis* exhibited significant antibacterial activity against *Staphylococcus aureus*, *Staphylococcus epidermis*, *Salmonella typhi*, *Salmonella paratyphi A* with MIC value ranging between 1-8 mg/ml [31]. The zone of inhibition and Minimum Inhibitory Concentration (MIC) of the extracts were determined and compared with the standard drugs ciprofloxacin and fluconazole. The chloroform extract was found to have both antibacterial and antifungal activity whereas the petroleum ether and ethanol extracts hold only antibacterial activity [32].

9.7 Anti-Oxidant activity

The free radical scavenging potential of the different extracts of leaves of *N. arbortristis* was evaluated in-vitro by employing diphenyl-picryl-hydrazyl (DPPH) assay method. The plant extracts reacted with DPPH, which is a stable free radical and converted it to 1, 1-diphenyl -1, 2- picryl, hydrazine which was measured at 517 nm. The scavenging effect of plant extracts and standard (ascorbic acid and BHT) on the DPPH radical decreases in the following manner: Ascorbic acid > Butanol > Ethyl acetate > BHT > Pet ether, and it was found to be 93.88% for ascorbic acid at concentration of 10 mg, for BHT, Butanol, Ethyl acetate and

Pet ether was found to be 97.42 %, 95.22%, 84.63% and 82.04% at concentration of 100 mg respectively. In this investigation different extract of *N. arbortristis* leaves possess concentration dependant free radical scavenging activity^[33].

9.8 Anti-Cancer activity

Fruit, leaf and stem methanol extracts of *N. arbortristis* were tested for in vitro anticancer activities. Moderate activity was observed at 30mg/ml conc. with 71% inhibition of dried *N. arbortristis* leaf methanol extract and least inhibitory activity was observed at 10mg/ml conc. With 86% inhibition of breast cancer cell lines free of pathogens. A high degree of against human breast cancer cell lines (MDA-MB 231) was observed with *N. arbortristis* dried fruit methanol and the IC₅₀ values were calculated to be 9.72mg and 13.8mg. The phytochemicals isolated from *N. arbortristis* dried fruit methanol are glycosides, tannins, phenols and steroids and are predicted to be responsible for this anticancer activity^[17].

9.9 Anti-Diabetic activity

The anti-diabetic activity of methanol extract of root of *N. arbortristis* is comparable to that of diabetic control animals. The extract poses safe and strong anti-diabetic activity. The extract was prepared by extracting 50g root powders with 400mL of methanol for 18 hours by hot continuous extraction method. The methanolic extract was filtered and partitioned by using petroleum ether to remove impurities. The solvent was evaporated under pressure and dried in vacuum. The dried extract *N. arbortristis* thus obtained was used for the assessment of hypoglycaemic activity. It reduces blood glucose level after seven days at the 500 mg/Kg in rats compare with standard drug. It was found that methanolic extract of *N. arbortristis* roots were more effective in reducing the blood glucose level compare to the standard drug^[34].

9.10 Anti-Malarial activity

Clinical study on 120 patients of malaria. Administration of fresh paste of medium sized 5 leaves of *N. arbortristis* thrice a day for 7-10 days has cured the disease in 92 (76.7%) patients within 7 days. Other 20 patients were cured by 10 days while the remaining 8 patients did not respond to the treatment. The paste was well tolerated and no severe side effects were reported. Screening of methanol and chloroform extract of leaves for mosquito larvicidal activity against 3 major mosquito vectors-*aedes aegypti*, *Culex quinquefasciatus* and *Anopheles stephensi* has found the two extracts to kill larvae of *A. stephensi* with LC₅₀ values of 244.4 and 747.7 ppm, respectively^[28, 35].

9.11 Anti-Parasitic activity

A crude 50% ethanolic extract of leaves have been reported to exhibit trypanocidal activity at 1000 g/mL concentration. In vivo studies revealed that the extract exerted anti-trypanosomal effects at doses of 300 and 1000 mg/Kg, significantly prolonged the survival period of *Trypanosoma evansi* infected mice. However, it is also reported that as soon as the treatment with the extract is discontinued, the parasitaemia increases and results in death of the experimental animals. *N. arbortristis* extract has also exhibited potential anti-leishmanial activity in *Leishmania donovani* infected hamsters. The 50% ethanolic extracts of the seeds, leaves, roots, flowers and stem of *N. Arbortristis* have been found to clear *Entamoeba histolytica* infections in rat caecum. However, the extracts were not active in vitro. The water soluble portions of ethanolic extract of flowers, bark, seeds and leaves of *N. arbortristis* were found to possess anti-

helminthic activity which is suggested due to inhibition of motility by relaxing and depressing responsiveness to contractile action of acetylcholine^[36, 37, 38, 39].

9.12 Anti-Trypanosomal Potential

Antitrypanosomal potential of a crude 50% ethanolic extract of *Nyctanthes arbor-tristis* leaves was evaluated in vitro and in vivo. The extract exhibited trypanocidal activity at the highest concentration (1000 µg/ml) tested. *In vivo* studies revealed that the extract exerted antitrypanosomal effects at doses of 300 and 1000 mg/kg, intraperitoneally and significantly prolonged the survival period of the *Trypanosoma evansi* infected mice. However, as soon as the treatment with the extract was discontinued, the parasitaemia increased and resulted in the death of the experimental animals^[39].

9.13 Anti-Viral activity

The ethanolic extract, n-butanol fractions and two pure compounds, arbortristoside A and arbortristoside C, isolated from the *N. arbortristis* possess pronounced inhibitory activity against encephalo myocarditis virus (EMCV) and Semliki Forest Virus (SFV). The in-vivo ethanolic extract and the n-butanol fraction at daily doses of 125 mg/kg weight protected EMCV infected mice against SFV by 40 and 60% respectively^[40, 41].

9.14 Anti-Leishmanial Activity

The anti-leishmanial activity of *N. arbortristis* has been attributed to iridoid glucosides, arbortristosides A, B, and C and 6-b-hydroxyloganin^[26]. The arbortristosides A, B, C, and 6-beta-hydroxy-loganin (Fig.2) exhibited both in vitro and in vivo anti-leishmanial activity against amastigotes in macrophage cultures and hamsters test systems, respectively^[42].

9.15 Anti-Histaminic and Anti-Tryptaminergic activity

The aqueous soluble of the alcoholic extract of *N. arbortristis* leaves (4.0 and 8.0g/kg oral) significantly protect against histamine aerosol - induced asphyxia (2% at 300 mm Hg) in guinea pigs. arbortristosid A and arbortristosid C present in *N. arbortristis* was reported to be anti-allergic^[43].

9.16 Anti-Cholinesterase activity

The aqueous extract of *N. arbortristis* stimulated the activity of acetylcholine esterase in mice, it antagonize the inhibition of this enzyme by malathion. The higher effects were seen in the serum than in the brain. The low anti muscarinic activity against acetylcholine induced contractions of isolated rabbit ileum was already reported^[38].

9.17 Anti-Nociceptive and Anti-Pyretic activity

The extract exhibited antipyretic effect against brewer's yeast-induced pyrexias in rats. When administered orally for six successive days in rats, it produced dose-dependend gastric ulcers. The aqueous soluble fraction of ethanolic extract of the leaves exhibited significant aspirin-like anti-nociceptive activity which was evidenced by inhibition of acetic acid-induced writhing in albino mice but fails to elicit morphine like analgesia which was tested via the rat tail flick and mouse tail-clip methods^[44].

9.18 Anti-Anemic Activity

A research was performed as hematological study on the ethanolic extracts of the flowers, barks, seeds and leaves of the plant and noticed the dose dependent rise in hemoglobin content and red blood cells count in rats. The extracts also

protect the decline of hemogram profile in anemic rats [22].

9.19 CNS depressant activity

It was reported that the leaves, flowers, seeds and barks (600 mg/kg) of *N. arbortristis* exhibited significant and dose-dependent prolongation of onset and duration of sleep and found to cause decrease in dopamine and increase serotonin level from which it can be resolved that the CNS depressant activity of the ethanol extracts of seeds, leaves and flowers may be due to the decrease in dopamine and increase in serotonin level [45].

9.20 Essential oils

The essential oil in the fragrant flowers, which is similar to the oil in *N. arbortristis*, is used as perfume [46].

9.21 Membrane Stabilizing Activity

From a research work of *N. arbortristis* isolated a carotenoid aglycone Ag-NY1 from the orange colored tubular calyx of flowers. Elucidation of the structure revealed that the carotenoid molecule is crocetin, which is the major aglycone present in the stigma of *Crocus sativus*. The compound exhibited a good membrane stabilizing activity as compared to the corresponding glycoside crocin [22].

9.22 Hepato-protective activity

The aqueous extracts of the leaves and seeds of *N. arbortristis* were found to have anti-hepatotoxic activity against carbon tetrachloride (CCl₄) induced hepatotoxicity [47, 48]. Further, it was established that the alcoholic and aqueous extracts showed significant hepatoprotective activity by reducing the levels of SGPT (serum glutamic pyruvic transaminase), SGOT (serum glutamic oxaloacetic transaminase) and serum bilirubin (total and direct). The results were supported by histopathological studies of liver samples which showed regeneration of hepatocytes by the extracts [49].

9.23 Sedative Activity

Sedative potential of a hot infusion of the flowers was examined in rats. In this test, male rats exhibited a dose-dependent conscious sedative activity while female rats remained unaffected. At these doses, muscle strength and coordi *Nyctanthes arbortristis* were not affected nor was blood glucose levels affected even at the highest dose. However, glucose absorption from the small intestine was significantly reduced. The sedation was attributed, in part, to the antioxidant and membrane stabilizing activity of the extract [50].

9.24 Treatment of Piles, Gout, Dry Cough

The seeds of *N. arbortristis* are used in treatment of piles. The decoction of *N. arbortristis* flowers are used in treatment of gout. Leaves are used against dry cough. The aqueous paste of leaves is used externally in treatment of skin related troubles specifically in treatment of ring worm. The young leaves are used as female tonic. *N. arbortristis* also has hypoglycaemic effect, potentiating action of exogenous insulin and streptozotocin-induced diabetic rat model [51].

9.25 Toxicity

N. arbortristis shown toxic effect of ethanolic extract of leaves in rats. The median lethal dose (LD) 16 gm/kg was observed in rats. No mortality was at 2.0 gm/kg while 75% mortality was seen at a 32 gm/kg dose. An administration of ethanol extract of the leaves (1, 2 and 4 gm/kg/day) orally for 6 consecutive days is produced gastric ulcers in rats. This

extract also showed irritant effects as it, dose-dependently, the formation of unformed semi-fluid collagenous pasty stools in albino mice because of a purgative effect. when extract instilled into the rabbit's eye produced conjunctival congestion with oedema, while the person who grounded the dried leaves developed vesicles on both palms [44].

9.26 Other activities

Acetone extract of the seeds exhibit ovicidal effect on the eggs of rice moth, *Corcyra cephalonica*. The inhibition of egg hatching increased with increase in concentration of plant extracts in contact toxicity test. 80.73% ovicidalaction was observed at 100% concentration of the extract. Petroleum ether extract of *N. arbortristis* also exhibits insecticidal activity against *Bagradacruiferarum*. The ethanolic extract of *N. arbortristis* leaves, seed and roots were screened for humoral and cell-mediated immune responses against *Candida albicans* and *Salmonella* antigens. The extracts showed protective effect due to arbortristoside A and C (Fig.2) (irridoidglucosides). The water soluble portion of an ethanol extracts of the leaves exhibit significant aspirin like anti-nociceptive activity but failed to produce morphine like analgesia. It was also found to possess anti-pyretic activity against brewer's yeast induced pyrexia in rats. The extract also produced gastric ulcers following oral administration for six consecutive days in rats. Ethanolic extract of the whole plant has been reported to initiate hair growth [52, 53] and hence used in dermatological disorder alopecia [9, 52, 54, 55]. It supports traditional use of the plant in treatment of hair loss [56]. Alcohol extracts of different parts of *N. arbortristis* are reported to possess antiallergic activity. Arbortristoside A and C isolated from the plant have demonstrated significant antipassive cutaneous anaphylaxis and mast cell stabilizing activity in rats [57]. The activity iscomparable to that of disodium cromoglycate. The n-butanol fraction of ethanolic extract as well as two pure compounds arbortristoside A and arbortristoside C isolated from *N. arbortristis* have been tested against encephalomyocarditis virus (EMCV) and Semliki forest virus (SFV).

10. Conclusion

The above work cited in the article of pharmacological activities is widely distributed in medicinal plant of *N. arbortristis* and it revealed the importance of herbal and ayurvedic pathway for effective treatment of various diseases considering its tremendous potential pharmacological activities. Animal studies enlighten on anti-pyretic, anti-bacterial, anti-viral, anti-inflammatory, hepatoprotective, anti-histaminic, anti-filarial, anti-oxidant, immune-protective activities of phyto-chemicals. *N. arbortristis* possessed a broad spectrum of activity against a panel of bacteria responsible for some common microbial disease in human and in plants.

N. arbortristis is widely distributed shrub useful for the treatment of dry cough, fungal skin infection, bronchitis, sciatica and rheumatism. Leaves are anti-bacterial, anti-inflammatory and anthelmintic. The flowers are bitter astringent, ophthalmic, stomachic and carmi of *N. arbortristis*. It is expectorant, bitter and tonic, febrifuge and mild purgative.

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