

# Water Lily (*Nymphaea nouchali* Burm. f): An Ancient Treasure of Food and Medicine

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## ABSTRACT

*Nymphaea nouchali* (Syn. *Nymphaea stellata* Willd.) from family Nymphaeaceae, is a species of perennial aquatic flowering plant with huge round floating leaves and rhizomes. It is well-known and prominent herb in Ayurveda and Siddha system of medicines with multiple medicinal properties. It comes from southern and eastern regions of Asia, and is a national blossom of Sri Lanka and Bangladesh. Scientific investigation has revealed that it exhibits vast range of pharmacological actions, namely antihyperglycemic, antioxidant, antimicrobial, analgesic, antiinflammatory, antipyretic, antitumor, hepatoprotective, antiulcer, antihelmintic, antinociceptive, immunomodulatory activities etc. Polyphenols, flavonoids, sterols, alkaloids, saponins, tannins, protein, nymphasterol, nymphayol have been recognized as important factors in the medicinal effects of *N. nouchali*. The present review focuses on pharmacological and phytochemical investigation of *N. nouchali*.

**Keywords:** *Nymphaea nouchali*, Blue water lily, Pharmacological actions, Phytochemistry.

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## INTRODUCTION

For generations, humans have historically depended on plants, animals, and minerals for basic requirements such as food, escape from enemies and hunting, treatment of infectious illnesses, and health concerns. According to the most recent estimates, 85% of the world's population relies significantly on herbal medicines as their major source of therapy and to provide basic medical needs, as herbal medicines have fewer side effects than pharmaceutical drugs. Despite the availability of modern treatment in many nations, herbal remedies have cultural and historical value. One of the most important and widely used medicinal plants for oriental therapies is *N. nouchali* (Blue water lily) (Figure 1). Water lilies are prehistoric aquatic blooming flora with huge round floating leaves and rhizomes. They are nearly 6 genera and 70 species collectively.<sup>[1]</sup>

*N. nouchali* (Nymphaeaceae) was formerly referred by synonym *Nymphaea stellata*.

## Taxonomic Hierarchy

Kingdom	:	Plantae
Subkingdom	:	Tracheophyta
Clade	:	Angiosperms
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Nymphaeales
Family	:	Nymphaeaceae
Genus	:	Nymphaea
Species	:	<i>nouchali</i> Burm.f.

## Vernacular names <sup>[2]</sup>

Sanskrit - Kumuda, Indivar, Nilakamala, Nilotpala, Utphala, Padma, Kamala, Indeevaram.

English -Blue water lily, Manel flower, Blue star water lily, Red water lily.

Tamil -Alli, Ambal, Vellambal, Nilotpalam.

Telugu - Allitamara, Kaluvapoovu, Kaluva, Neelattamara.

Marathi - Kamoda, Neel Kamal.

Hindi - Neel Kamal, Kumudinee.



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**Figure 1:** *Nymphaea nouchali* flower in a local pond.

Photograph by Basani Kiranmai and Ashok Kumar Tiwari.

Malayalam - Ambalpoovu.

Bengali - Kumud, Sundi.

Gujarati - Poyanu

Kannada - Neeltare

Punjabi - Kamalini

Urdu - Neelofar

Assamese - Bogabhet, Seluk

*N. nouchali* is a perennial aquatic herb that spreads extensively in mixed populations in almost every shallow natural water body. It is utilized as a decorative plant due to its magnificent flowers. It is an inherent part of numerous socio-ethnic devout activities, practices, beliefs, celebrations, ceremonies, and legacies. Although *N. nouchali* is not lotus, it is occasionally referred to as the “blue lotus of India”.<sup>[3]</sup>

## History

Aquatic lilies were identified in Portugal in the Mesozoic period. It originates from the Greek for “nymph”. Nymphs were designated as guardians of spring and rivers in Greek mythology. Several centuries prior, Europeans, Asians, and Africans used the seeds and tubers of water lilies as nourishment during the period of famine. Water lilies are native to Egypt, and are very much important in their religion and history. Egyptians consumed the rhizomes, flowers, and leaves, while the buds were commonly depicted on antiques, paintings, and ancient monuments. Moreover, according to the Egyptian royal dynasty, water lily blossoms symbolise purity and longevity. The blue water lily rootstock was consumed by South Africans in the mid-18<sup>th</sup> century, either raw or cooked in curries.<sup>[4]</sup>

## Symbolism

Lord Krishna’s dark complexion is likened with Neel Kamal. Based on this, the blue water lily is also known as Krishna Kamal. This flower is considered one of Goddess Durga’s favourite flowers. In traditional Hindu scripture Krittivas Ramayans, this flower’s fascinating back-story is as follows: It is said that to save his abducted wife Sita from Ravana, the monster king in Lanka, Rama travelled to the country known as “Lanka”. Before final conflict with Ravana, Lord Ram rushes to Goddess Durga to ask for her blessings. He realized that the Goddess would be pleased if she is worshipped with 108 ‘Neel Kamal’ or Blue water lilies. Although he could arrange 108 flowers to worship Goddess, at last he found that one flower was mysteriously missing at final offering. Frustrated with this, he took the arrow to offer her one of his eye ball resembling Neel Kamal. Goddess stopped him doing this, became pleased with his devotion, and blessed him to win the battle. Even to this day; these blue water lilies are presented to Goddess Durga during Durga puja.

*N. nouchali* represents as national blossom of Bangladesh and Sri Lanka. Since ancient times, its gorgeous blossom has been referred to as a sign of good value, order, and wholesomeness in Sanskrit, Pali, and Sinhala historical works under the titles *Kuvalaya*, *Indhiwara*, *Niluppala*, *Nilothpala* and *Nilupul*. According to Buddhism, this blossom represents one of the 108 symbols on the footprints of Prince Siddhartha, the Gautam Buddha. According to mythology, the lotus flower blossoms wherever Buddha has travelled during his lifetime after his passing.<sup>[5]</sup>

## Description

*N. nouchali* is non-viviparous species having immersed bases and branches that blooms throughout the day. The structure of leaves is broad, flattened, spherical, or ovate-orbicular in form. Asymmetric, drifting, petiolate veined, long-petiolate, sinuate, hairless, and both sides green are further possible characteristics (Figure 2A). The leaves, with slightly upturned edges, are crucial for maintaining the plant’s flotation. The leaves can be immersed or hovering in the water. They range in size from 20 to 23 cm, and they can extend up to 1.5 m from the rhizome. It has thick dark spongy tuberous rhizome (Figure 2B).

This aquatic lilies have an attractive blossoms, often purple-blue in colour with red corners. Certain varieties have lavender, fuchsia or lilac colored; hence it is named as red and blue water lily. Water lilies have huge, axillary or single blooms that vary in size. The blooms emerge with 4-5 sepals, 13-15 petals, few pistils and numerous filaments. The flower’s pistils are encircled by a dense ring of stamens. It is a hermaphroditic plant because the blossoms have both pistil and stamen. The flower opens in the morning and completely shuts in the mid-evening. Flower remains shut at nights. The pleasant aroma of flowers can entice insects to stop by. The curved shaped sepals are about 4-15 cm in

diameter and 5-20 cm above the water, the flower stalks can reach 1.5 m length (Figure 2C).<sup>[6]</sup>

The fruit of this plant is depressed globose syncarp, berry-like structure, a diameter of 2.5-3 cm, ripens in water, erratically fissured and has many seeds. Seeds are ellipsoid- globose, 1-1.5 m long, greyish-white, horizontally ridged, buoyed by a vesicle-like mucous membrane surrounded by air sacs (Figure 2D).<sup>[7]</sup>

*N. nouchali* is broadly spread and seen in regular and locally dominant in permanent and temporary water bodies in India. It has been grown throughout Southeast Asia for ages, especially close to temples. It is native to Sri Lanka, Bangladesh, India, Borneo, Philippines, Nepal, Thailand, China, Myanmar, Malaysia, Laos, Afghanistan, New Guinea, Pakistan, Cambodia, Taiwan, Vietnam, Indonesia and Australia.<sup>[8,9]</sup>

### Cultivation

*Nymphaea* is a supreme genus of decorative flora.<sup>[10]</sup> *N. nouchali* is planted in agricultural areas which are unoccupied in the rainy season. Roots and seeds are grown in mud before being transferred to locations spaced 2.5 m wide. It is possible to raise blue water lilies using seedlings, but their blooming period is 36 months. Seeds can be cultivated from February to June. Thinly scattered seeds must be gently enclosed with soil, submerged in water no more than 3 cm deep, and then grown in bright location. It will take 4 to 5 weeks for germination. The sapling must be selected, placed into separate pots, and then placed down into the water as soon as the first two or three leaves develop. Division is the simplest type of propagation.<sup>[11]</sup>

### Traditional Uses

*Nymphaea nouchali* is a well-known and prominent herb in Ayurveda and Siddha formulations meant for diabetes, swelling, hepatic diseases, kidney problems, and menstruation issues. The whole plant is utilized as medicine for diabetes, eye problems, indigestion, and as a cardiac stimulant.<sup>[12,13]</sup>

Over the dry season, dry plants are harvested from lakes, tanks, and wetlands, and utilised as animal feed in India. Rhizome and stem infusions are recommended as emollients and diuretics to treat blennorrhagia, and urinary tract diseases.<sup>[14]</sup>

The seeds and stems of this water lily are also found in some traditional medicines and folk medicines. The roots and flowers show mild sedative effect; often used to boost mental alertness.<sup>[15]</sup>

### Flower

In Thailand and India, the blossoms are utilised as a heart tonic due to their astringent action. The Ayurveda and Siddha system of medicine employ them to manage diabetes mellitus and liver problems.<sup>[16]</sup> The acrid, bitter-sweet flavour of water lily blooms

aids to purify the blood, calm coughs, and acts as an aphrodisiac alongside nausea, dizziness, worm infection, and skin burns. The flower's infusion serves to heal heart palpitation and as a narcotic; and the syrup is employed to treat dysuria, high fevers, apoplexy, and brain inflammation. Flowers fibres are astringent in nature and used to calm scorching feeling, hemorrhoids and menstrual issues.<sup>[17]</sup>

### Seeds

In Nigeria, Ghana and India, they are considered to be cooling medicine, and are used to treat fever and skin conditions like eczema. The seeds are used to promote appetite and considered curative.<sup>[16]</sup> The seed powders are used in part for making chapatis (bread) meant for diabetic people.<sup>[18,19]</sup>

### Rhizome

Rhizomes of *N. nouchali* are used to relieve pain and irritations and applied in cases of diarrhea, indigestion, and utilized as emollient, diuretic, for back and stomach ache in South-East Asia.<sup>[20]</sup> They are astringent and tonic in nature. Rhizome paste is thought to treat menstruation irregularities and gastrointestinal issues. In SriLankan folk medicine, the rhizome is consumed to heal cystitis, nephritis, fever and sleeplessness.<sup>[21]</sup> In Vietnam and Cambodia, the rhizomes are utilized to cure back and abdominal pain. Rhizome powder is recommended as emollient for hemorrhoid in India.<sup>[22]</sup>

### Leaves

In erysipelas problem leaves are used tropically, and in Cambodia they are utilized as a component in topical cream for eruptive heat.<sup>[18]</sup> In Philippines, gonorrhoea is treated with the mildly sour liquid from leaves. Leaves have moderate anesthetic effect and are used to treat insomnia by smearing on forehead.<sup>[16]</sup>

### Roots

Roots are employed to cure infertility, hyperglycemia, blennorrhagia, kidney problems, and as diuretics.<sup>[23]</sup> Powder is recommended for indigestion and hemorrhoid.<sup>[24]</sup>

### Rhizome and Flower

They are antiseptic, relieve pain, induce sleep and employed to cure inflammations, as a mouthwash for pharyngitis, administered orally to cure prostate issues.<sup>[25]</sup>

### Petioles

Grinding the petioles with salt, Cuminum cyminum powder, jaggery and ghee mixed with the paste is used to treat heavy menstrual discharge. During pregnancy, stripes with *Pinus longifolia* roots are used to cure fever, diarrhea, sickness, cough, dizziness, discomfort, and bleeding.<sup>[26]</sup>

## Edible uses<sup>[27]</sup>

In some countries like India and Bangladesh, the seeds are boiled or grounded into flour and substituted with wheat or millet flour in meal preparation or bread production.

The seeds are also consumed as snacks by mixing them in caramel, formed into balls or making them fried in ghee or oil until they are popped, like amaranth or quinoa.

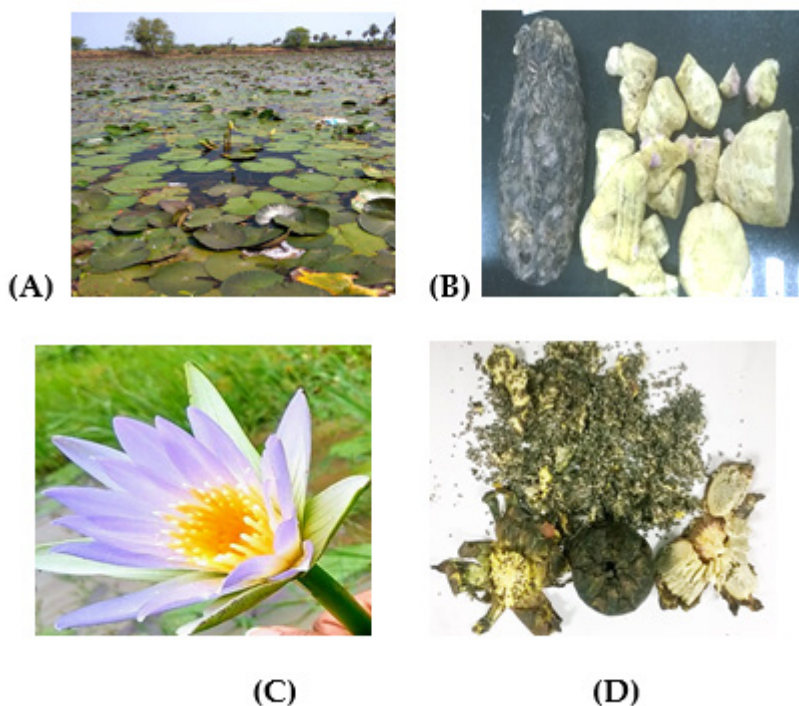
Rhizomes are used as nutrition especially in preparation of vegetables and consumed simmered as well as grilled. The powdered rhizomes are also used in preparation of oatmeal. A famine food, the rhizome is considered to be poisonous unless it is cooked. Flowers are used as vegetables. Leaves and blossom stalks are consumed as veggies. In Sri Lanka, dishes are made from the delicate leaf and blossom peducles.

## Pharmacological actions

### Antidiabetic activity

Aqueous methanolic extract of *N. nouchali* rhizomes were investigated for antihyperglycemic activity. Numerous antidiabetic and antioxidant compounds were discovered by metabolomics screening. Boiled rhizome powder had showed strong antihyperglycemic action in rats against sugar-induced postprandial hyperglycemia.<sup>[28]</sup> The methanolic extract of

seeds and tuber inhibited pancreatic lipase and intestinal  $\alpha$ -glucosidase. These characteristics could minimize the occurrence of diet-related postprandial hyperlipidemia and hyperglycemia. The findings of this study demonstrate that tuber and seeds can be utilized as an essential nutritional complement to counter the advancement of diet-induced hyperglycemia and hyperlipidemia.<sup>[29]</sup> Ethanolic extract of leaves have been observed to display dose depended hypoglycemic activities in alloxan induced diabetic rats along with reducing the levels of cholesterol and triglycerides.<sup>[30]</sup> Nymphayol isolated from chloroform extract of flower has been reported to exhibit hyperglycemic activity by increasing insulin content and reducing blood sugar level in diabetic rat.<sup>[31]</sup> Hydroethanol extract of flower was investigated for antihyperglycemic and hypoglycemic impact on normal and alloxan-induced diabetic rats. The findings represented that flowers exhibit antihyperglycemic action in diabetic rats induced by alloxan but no hypoglycemic action in normoglycemic rats.<sup>[32]</sup> Ethanolic extract of flower displayed antihyperglycemic and antihyperlipidemic properties in diabetic rat induced by alloxan along with reducing levels of urine sugar, blood urea and rise in body weight, protein, plasma insulin.<sup>[33]</sup> *N. stellata* flower displayed considerable intestinal  $\alpha$ -glucosidase inhibitory action, which is helpful in preventing hyperglycemia in diabetic patients without causing any toxicity.<sup>[34]</sup> The findings show that *N. nouchali* is a good source of natural antidiabetic agent.



**Figure 2:** (A) *N. nouchali* leaves, (B) *N. nouchali* whole and peeled cut pieces of rhizome. (C) *N. nouchali* flower, (D) *N. nouchali* fruit bulb and dispersed seed.

Photographs by Ajay Anand and Ashok Kumar Tiwari. Geographical source

## Antioxidant activity

*N. nouchali* flower displayed antioxidant activity.<sup>[35]</sup> Methanolic extract of *N. nouchali* flower showed good antioxidant potentiality.<sup>[36,37]</sup> Hydroalcoholic extract of seeds were evaluated for phytochemical constituents and antioxidant activity and results indicated that seeds are excellent source of antioxidants.<sup>[38]</sup> Examination of *N. nouchali* leaves to assess its antioxidative capacity revealed that it has potent antioxidant activities.<sup>[39,40]</sup> Aqueous methanol extract of seeds and tubers showed strong free radicals scavenging activities and reducing power. They had strong inhibitory action on the production of different advanced glycation end products, which is a crucial factor in the development of postprandial oxidative stress.<sup>[29,41]</sup> In RAW264.7 cell, the t-BHP-induced oxidative stress was ameliorated by *N. nouchali* flower which provides evidence of its antioxidative stress properties.<sup>[42]</sup> Methanolic extract of boiled rhizomes displayed potent antioxidative activity.<sup>[28]</sup> The phytochemical analysis of its stem disclosed the presence of antioxidant activities working through multiple mechanisms.<sup>[43]</sup>

## Antimicrobial activity

Hydroalcoholic extract of seeds revealed great zone of inhibition for *P. aeruginosa*, *S. aureus* and *C. albicans*.<sup>[44]</sup> Flowers were active against *P. aeruginosa*, *B. cereus* and *S. aureus*.<sup>[45]</sup> The antimicrobial activity of flowers was seen against *S. paratyphi* A.<sup>[46]</sup> Methanolic extract of *N. nouchali* flower displayed greater protection from *B. subtilis* and *S. lutea* than nalidixic acid.<sup>[47]</sup> The ethanolic extract of leaves has demonstrated protection against *E. coli*.<sup>[48]</sup> Numerous endophytic fungi are found inside the *N. nouchali* which were active against *P. aeruginosa*, *E. coli*, *S. aureus* and *B. cereus*.<sup>[49]</sup> *N. nouchali* flower showed significant antibacterial and antifungal activities against *V. parahemolyticus* and *S. boydii*.<sup>[35]</sup> The findings support the plant's traditional use in the treatment of infections and show that the *N. nouchali* can be employed as a possible antimicrobial agent.

## Analgesic and antiinflammatory activities

Methanolic extract of flower has been exhibited to possess analgesic activity using torsion and formalin assay and reduce inflammation in carrageenan induced posterior leg edema test.<sup>[31]</sup> *N. nouchali* plant was found effective in peripheral analgesic action using acetic acid-induced tail twisting and dipping methods and using formalin induced pain method analgesic effect in mice.<sup>[50]</sup> Methanolic extract of *N. nouchali* leaves showed significant antiinflammatory activity using HRBC method.<sup>[51]</sup>

## Antihepatotoxic activity

*N. stellata* flower extract has shown hepatoprotective activity against CCl<sub>4</sub>-induced liver injury in rats for 10 days by increase in bilirubin, marker enzyme, lipid peroxidation and decrease

in glutathione, glycogen and catalase action.<sup>[52]</sup> Seeds extract also protected against CCl<sub>4</sub>-induced hepatic injury in mice. The seeds decreased the lengthening of sleep time and avoided CCl<sub>4</sub> induced increase in liver mass as well as necrosis of the liver.<sup>[53]</sup> Ethanolic extract of flower was tested against CCl<sub>4</sub>-induced hepatic necrosis in Wistar rats. In the CCl<sub>4</sub>-induced group, elevated values of albumin, bilirubin, SGOT, SGPT are indicative of liver necrosis. A considerable recovery effect was seen after pre-treatment with *N. nouchali* flower extract, much like with the standard drug silymarin.<sup>[54]</sup>

## Antinociceptive activity

Nymphayol isolated from *N. stellata* flower was analyzed for antinociceptive activity using writhing acetic acid, formalin-induced paw licking assay. Nymphayol significantly reduced the stretching and writhing induced by acetic acid as well as late stage of paw licking response.<sup>[55]</sup> Methanolic extract of flowers has been observed to display reliable, substantial, and dose-dependent antinociceptive activity using tail dip assay (heat induced), acetic acid torsion test (chemical induced pain model).<sup>[56]</sup>

## Immunomodulatory activity

Nymphayol was evaluated for immunomodulatory action using neutrophil adhesion assay, delayed-type hypersensitivity, humoral reaction to sheep erythrocytes, cyclophosphamide induced myelosuppression and phagocytic activity. Nymphayol pre-treatment induced rise in neutrophil adhesion. Rise of antibody in mice showed that nymphayol improved humoral immunity against sheep erythrocytes. Nymphayol administered orally to mice augmented the cell-mediated hypersensitivity response brought on by sheep erythrocytes. The results showed nymphayol has immunomodulatory activity.<sup>[49]</sup> The whole plant extract of *N. nouchali* was examined for immunomodulatory activity using NBT dye test and cellular lysosomal enzyme activity technique. In the peritoneal macrophage phagocytosis assay, the extract had a positive dose-effect with increased activity at 0.5 mg/ml and increased activity for activated lysosomal activity at 0.25 mg/ml. According to the results, *N. nouchali* has a strong immunomodulatory action.<sup>[57]</sup>

## Antipyretic activity

Nymphayol isolated from flower was examined for antipyretic activity using yeast induced hyperthermia in rats and showed substantial ( $p < 0.05$ ) decrease in fever induced by yeast in rats. These findings propose that nymphayol possess antipyretic activity.<sup>[55]</sup>

## Antihelmintic activity

The thalamus from *N. nouchali* was checked for antihelmintic activity against *P. posthuma*. The extract was tested in the bioassay with various doses (5-20 mg/ml) and the timing of worm's

paralysis and demise was determined. The antihelmintic activity of alcoholic and chloroform extract were discovered to be more effective than standards Albendazole and Piperazine xitrate.<sup>[58]</sup>

### Antitumor activity

The methanolic extract of *N. nouchali* roots were evaluated for their ability to prevent Raji cell-based tumour promoter HPA from activating human herpes virus. With zero inhibitory rates, the extract was inactive.<sup>[59]</sup> In MCF-7 breast cancer cells, nymphayol displayed a strong antiproliferative actions by inducing apoptosis in cells and alteration of pathways regulated by mitochondria.<sup>[60]</sup>

### Antiulcer activity

Antiulcerogenic activity of the nymphayol was estimated using mouse model of ethanol-induced ulceration. According to the findings, nymphayol exhibited gastroprotective action.<sup>[61]</sup>

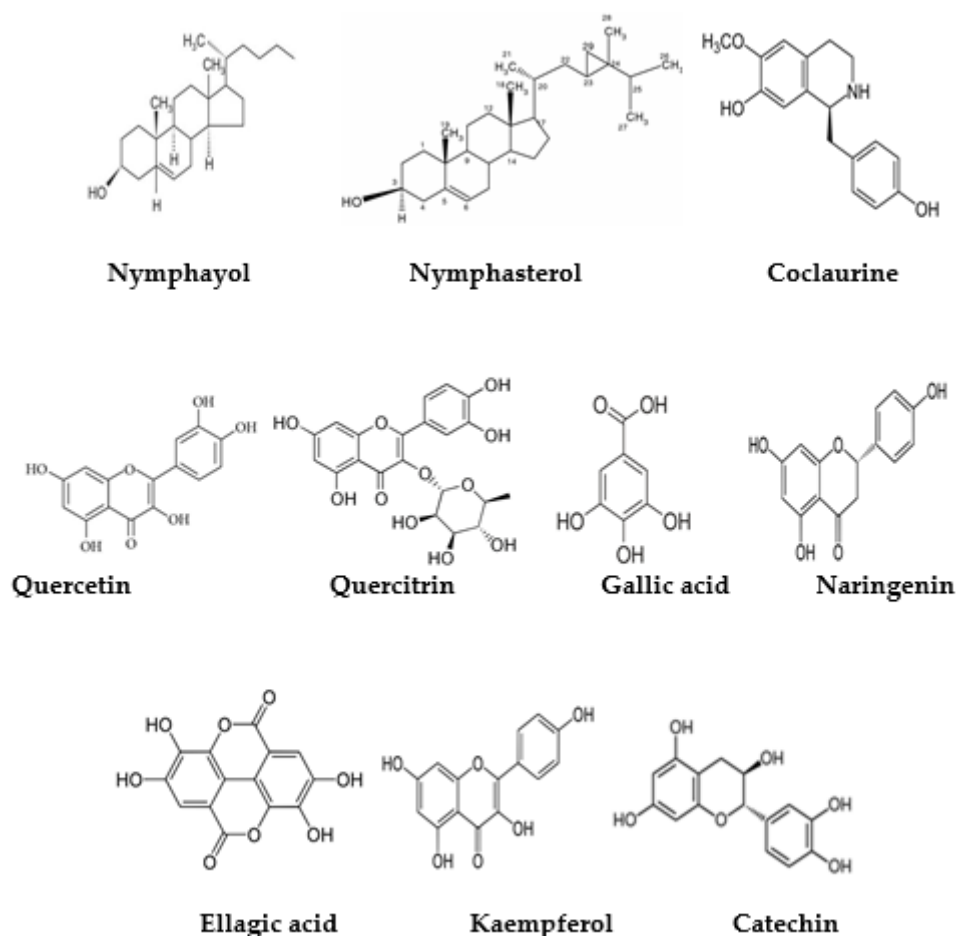
### Phytochemistry

Several phytochemicals have been identified from different parts of *N. nouchali*. Some notable ones are shown in Figure 3. Sterols, saponins, alkaloids, flavonoids, and polyphenols have

been detected in different solvent extracts of complete plant. A novel sterol, nymphasterol, was discovered from a methanol extract of *N. Stellata* seeds.<sup>[62]</sup> A novel sterol called nymphayol was discovered in a flower's chloroform extract.<sup>[31]</sup>

Coclaurine, a phenolic basic alkaloid, is found in the aerial parts of *N. stellata*. Seeds are reported to contain proteins, polyphenols, cellulose and pectin.<sup>[64]</sup> Coclaurine has been reported to exhibit anticonvulsant,<sup>[65]</sup> anticancer,<sup>[66]</sup> HIV inhibitory,<sup>[67]</sup> hypoglycemic,<sup>[68]</sup> and antioxidant effects.<sup>[69]</sup>

In flower, quercetin, gallic acid, ellagitannin, methyl gallate, 3-methylkaempferol, kaempferol-3-O-glucoside, flavonol, isorhamnetin were identified.<sup>[70,71]</sup> Isolation of linoleic acid, 10-eicosenoic acid, quercitrin and vasicinone from flowers is also reported.<sup>[72]</sup> Quercetin is reported to exhibit antioxidative capacity,<sup>[73]</sup> fight against cancer<sup>[74]</sup> and virus,<sup>[75]</sup> antidepressant, antihyperglycemic, antiarthritic and wound healing properties.<sup>[76]</sup> Gallic acid contains several health promoting properties like anticancer,<sup>[77]</sup> antioxidant and antimelanogenic<sup>[78]</sup>, reduce inflammation<sup>[79]</sup> and protection from microbes.<sup>[80]</sup> Quercitrin is reported to exhibit antiinflammatory,



**Figure 3:** Phytochemicals with broad spectrum biological activities from *N. nouchali*.

immunomodulatory activities along with analgesic,<sup>[81]</sup> and antioxidant effects.<sup>[82]</sup>

Steroids have been found in the stem of *N. stellata*, including stigmastanone, stigmastanol, stigmast-5,22-dien-3-one.<sup>[83]</sup> Gallic acid from dried flower's hydroalcoholic extract have been quantified using HPTLC.<sup>[84]</sup> Gallic acid, caffeic acid, kaempferol, catechin, luteolin, epigallocatechin, epicatechin gallate were identified as the major polyphenolic compounds by HPLC analysis in *N. nouchali* leaves.<sup>[40]</sup> According to findings, catechin displays antidiabetic properties, prevention from cancer and infections, and antiulcerogenic action.<sup>[85]</sup> Kaempferol has several health promoting properties that aid in the prevention of illnesses.<sup>[86]</sup>

There have been findings of nuciferine, n-nornuciferine and apomorphine.<sup>[87]</sup> *N. nouchali* stems contains in abundance the important minerals like Na, Ca, K, P, Mg and trace elements like Zn, Fe, Cu.<sup>[88]</sup> Furfural, 2-phenylmethylpiperidine, Tetrahydro-4H-pyran-4-ol, Glycylsarcosine, 1-amino-2,6 dimethyl piperidine, 2-phenylmethyl piperidine, 2-Furancarboxaldehyde, Benzoic acid, ace oxyacetic acid, benzenethiol, cyclohexanol, 2 methylene-6 methyl, 3-methoxybenzoic acid,  $\alpha$ -linolenic acid, were quantified using GC-MS analysis from *N. nouchali* petals.<sup>[89]</sup> Ag nanoparticles were synthesized from *N. stellata* plant.<sup>[90]</sup>

The tuberous rhizome of *N. nouchali* is rich in polyphenols and flavonoids and has been shown to be a nutrient-rich healthy food that treats diseases.<sup>[41]</sup> Gallic acid, tryptophan, ellagic acid, quercitrin, naringenin, and pendunculagin-1 isomer were quantified using UPLC-Q-TOF-MS analysis from *N. nouchali* rhizome.<sup>[28]</sup> According to the study, naringenin has protective effect against cancer, virus, microbes,<sup>[91]</sup> and has antioxidant, and antidepressant effects.<sup>[92]</sup> Ellagic acid is reported to have anti-atherogenic,<sup>[93]</sup> antiproliferative,<sup>[94]</sup> anti-tumor,<sup>[95]</sup> antioxidant<sup>[96]</sup> and antiinflammatory effects.<sup>[97]</sup> Amino acids like proline, alanine, glutamic acid, aspartic acid, butanedioic acid, benzoic acid, butanoic acid, xylitol were identified using GC-MS analysis. Sugars and sugar acids mainly D-mannose, D-glucose, D-galactose, sucrose, D-fructofuranose, ribonic acid and D-talose and fatty acids like hexadecanoic acid, octadecanoic acid, tetradecanoic acid, docodanoic acid, elaidic acid and linolelaidic acid were discovered from *N. nouchali* rhizome.<sup>[28]</sup>

Rutin, myricetin, gallic acid, catechin, quercetin, vanillic acid, ellagic acid, rosmarinic acid and p-coumaric acid were detected from methanol extract of *N. nouchali* tubers using HPLC-DAD analysis.<sup>[98]</sup>

## CONCLUSION

Since diseases evolve through time, the effective therapies should also evolve alongside. Herbal medicines are considered to have fewer side effects than pharmaceutical drugs, and it is believed

that 85% of the world's population relies on herbal medicines as their main source of therapy. *N. nouchali* contains ample amounts of polyphenols, flavonoids, amino acids, sugars, fatty acids, alkaloids, protein, and sterols and was demonstrated that it is healthy food rich in nutrients which can aid in treating disorders. It is the traditional plant that has several ceremonial applications in Indian culture along with therapeutic applications such as antidiabetic, and antioxidant properties, antimicrobial, antihepatotoxicity, antiinflammatory, analgesic, antiulcerogenic, antitumor, antipyretic, immunomodulatory. Future pharmacological research should focus on thoroughly examining unproven activities and their efficacy in treating urinary diseases, menorrhagia, blennorrhagia and menstrual irregularities.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

## ABBREVIATIONS

*N. nouchali*: *Nymphaea nouchali*; *N. stellata*: *Nymphaea stellata*; *P. aeruginosa*: *Pseudomonas aeruginosa*; *S. aureus*: *Staphylococcus aureus*; *B. cereua*: *Bacillus cereua*; *C. albicans*: *Candida albicans*; *S. paratyphi*: *Salmonella paratyphi* A; *B. subtilis*: *Bacillus subtilis*; *S. lutea*: *Sarcinalutea*; *E. coli*: *Escherichia coli*; *V. parahemolyticus*: *Vibrio parahemolyticus*; *S. boydii*: *Shigella boydii*;  $\text{CCl}_4$ : Carbon tetrachloride.

## SUMMARY

*Nymphaea nouchali* is perennial aquatic flowering plants that belongs to Nymphaeaceae family. *N. nouchali* has traditionally been used to cure of various ailments. This review has highlighted the history, traditional and edible uses, pharmacology, and phytochemistry of *N. nouchali*. The review would be beneficial to people working in the fields of phytochemistry and pharmacology and also the farmers and tribal people to protect and cultivate this aquatic plant for health and wealth.

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