Journal of Cardiovascular Disease Research
ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 04, 2024

In depth review on Phytochemicals, taxonomy, botanical description and Physiological Significance of Nelumbo nucifera

Akash Sharma[1], Anil Kumar[2], Ajit Kiran Kaur[3], Dakshayini[4], Seena KX[5], Ujwala Sandip Dube[6], Gaurav Goyanar[7,] Uriti Sri Venkatesh[8], Mathews T Thelly[*9]

[1]Assistant Professor, Institute of Pharmacy, Assam Don Bosco University, Guwahati, India
[2]Assistant Professor & Head, Department of Chemistry (PG), Sahibganj College Sahibganj, Jharkhand, India
[3]Professor, Department of Pharmacy, Accurate college of Pharmacy, Greater Noida, Uttar Pradesh, India
[4]Guest Faculty, Department of Biosciences, Biotechnology unit, Mangalore University, Mangalagangothri, Mangalore, Karnataka, India
[5]Professor, Department of Pharmacognosy, Indira Gandhi Institute of Pharmaceutical Sciences, Perumbavoor, Kerala, India
[6]Professor, Department of Pharmacognosy, Ideal College of Pharmacy and Research, Kalyan , Maharashtra, India
[7]Associate Professor, Department of Pharmacognosy, Institute of Pharmaceutical Sciences, SAGE University , Indore,Madhya Pradesh, India
[8]Assistant Professor, Department of Pharmacology, Sri Sivani college of Pharmacy, Srikakulam, Andhra Pradesh, India
[*9]Associate Professor, Head and Research Guide , Department of Botany, Kuriakose Elias College Mannanam, Kottayam, Kerala, India

Corresponding Author: Dr. Mathews T Thelly, Associate Professor, Head and Research Guide , Department of Botany, Kuriakose Elias College Mannanam, Kottayam, Kerala, India

Article Submitted on 30/03/2024 | Article Revised on: 10/04/2024 | Article Accepted on: 15/04/2024

ABSTRACT

Sacred lotus, or Nelumbo nucifera, is a popular therapeutic herb. Since ancient times, lotuses have been utilized as food and medicine in India, Egypt, the Middle East, and China. The lotus has edible blooms, seeds, leaves, fruit, and rhizomes. In Asia, the rhizome is frequently used as a component in soups and stir-fries, while the flower's petals are used to wrap food. In many medical systems, including folk medicine, Ayurveda, Chinese traditional medicine, and eastern medicine, all sections of N. nucifera have been employed for therapeutic purposes.To this day, several chemical

components have been identified. Nonetheless, alkaloids and flavonoids make up the majority of the lotus's bioactive components. The lotus plant was traditionally used as an astringent, emollient, and diuretic. It was used to the management of tissue inflammation, diarrhea, and homeostasis. Because the rhizome extract contains asteroidal triterpenoid, it has been utilized for its anti-inflammatory and antidiabetic effects. For hematemesis, epistaxis, bleeding, hematuria, and metrorrhagia, leaves were a useful medication. Flowers have been utilized to cure a high temperature, cholera, hyperdipsia, and diarrhoea. In conventional healthcare, seeds have been utilized as an antidote for poisons, to cure leprosy, skin conditions, cancer, and tissue inflammation. In traditional Chinese medicine, lotus seed embryos are used to treat cardiovascular illnesses, neurological problems, and sleeplessness. Lotus has nutritional benefits in addition to medicinal value. This review aims to clarify Nelumbo nucifera's phytochemicals, taxonomy, botanical description, and physiological importance.

KEY-WORDS

Nelumbo nucifera, Inflammation, Physiological, Phytoconstituents, Immunomodulator

INTRODUCTION

Native or conventional medicine refers to medicinal practices created by the local ethnic community using natural minerals and plants. Every region of the globe has a unique history of conventional medicine. For instance, traditional Chinese medicine and acupuncture started in China, whereas ayurveda medicine developed in Southeast Asia and unani medicine in the Middle East and Arab nations [1-3]. Secondary metabolites found in herbal plants include flavonoids, tannins, alkaloids, glycosides, terpene, and steroids. Certain chemicals, such phenols or their oxygen-substituted derivatives, like tannins, are physiologically active and can be used to cure or prevent disease in both people and animals. Other chemicals may include sulfur or nitrogen.

Antioxidant activity is exhibited by polyphenols, and this has several health advantages [4, 5]. In addition to their biological effects on humans, these compounds serve as defensive systems for plants against their predators. Many of these botanical items and spices have been used medicinally by humans since ancient times [6].

With several popular names (such as Indian lotus, Chinese water lily, and holy lotus) and synonyms (Nelumbium nelumbo, N. speciosa, N. speciosum, and Nymphaea nelumbo), Nelumbo nucifera is now classified as a monogeneric family within the Nymphaeaceae family.[7–12] There are several therapeutic applications for every portion of N. nucifera. Pharyngopathy, pectoralgia, spermatorrhoea, leucoderma, smallpox, dysentery, cough, haematemesis, epistaxis, haemoptysis, haematuria, metrorrhagia, hyperlipidemia, fever, cholera, hepatopathy, and hyperdipsia are among the traditional ailments treated with the leaf, rhizome, seed, and flower. This plant is also used in Ayurveda to cure strangury, vomiting, leprosy, skin conditions, and nervous weariness. It is also used as an anthelmintic and diuretic.[13–15]

It is employed as an antidote to poisons and to treat skin conditions, cancer, leprosy, and tissue inflammation.[16,17] From the leaf, rhizome, seed, and flower, a number of pharmacologically active components that are liable for the therapeutic properties have been identified. Numerous phytoconstituent classes have been identified from different N. nucifera sections. Alkaloids, steroids, triterpenoids, flavonoids, glycosides, and polyphenols are among the most significant classes.[18–19] Numerous pharmacological properties of N. nucifera have been demonstrated by studies on its various components. various sections' extracts have demonstrated anti-ischaemia, antioxidant, antiviral, cancer-preventing, anti-obesity, lipolytic, hepatoprotective, hypocholesterolaemic, antipyretic medication, antidiarrheal, antimicrobial, anti-inflammatory, and diuretic.[20–24]

TAXONOMY[25]

Kingdom	Plantae -Plants
Subkingdom	Tracheobionta - Vascular plants
Superdivision	Spermatophyta - Seed plants

Division	Magnoliophyta - Flowering plants
Class	Magnoliopsida - Dicotyledons
Subclass	Magnoliidae
Order	Proteales
Family	Nymphaeaceae /Nelumbonaceae - Lotus-lily family
Genus	Nelumbo Adans. - Lotus
Species	nucifera Gaertn. - Sacred lotus

SYNONYMS: [26]

English	Sacred lotus
Hindi	Kanwal, Kamal
Sanskrit	Ambuja
Tamil	Ambal, Padma, Pankaja, Kamala
Bengal	Padma
Persian	Nilufer
Malayalam	Tamara
French	Nelumbo
German	Indische lotosblume
Gujarat	Suriyakamal

BOTANICAL DESCRIPTION

Nelumbo nucifera is a perpetual aquatic plant that grows in the muck at the bottom of small ponds, lakes, lagoons, marshes, and flooded fields. Its rhizomes, which are sometimes mislabeled "roots," Large, peltate (the leaf stalk attaches to the center of the leaf rather than the margin) leaves rise on 1 to 2 m long petioles above the water's surface.[27–29] Lotus may reach a height of around 150 cm and a spread of 3 meters horizontally. The striking blooms may have a diameter of up to 20 cm, while the leaves can reach up to 60 cm in diameter. The fruits are in the form of a conical pod with holes that hold the seeds within.

Large, both aerial and floating orbicular leaves with diameters ranging from 20 to 90 cm, sharp tips that abruptly become short, petiolate, whole glaucous, non-wettable, powerful cupped leaves in the event of aerial departs and flat leaves in the the event of gliding ones, and radiately nervous, leathery when fresh, almost transparent and brittle upon drying, and dotted with a slightly brownish red pigment on the lower surface. The petals of the high leaves are straight and stout white, while those of the floating leaves are not strong enough. The typical length is from 23 to 30 cm for floating leaves and 24 to 33 cm for aerial leaves. The petals are smooth, green or green brown in color having tiny brown spots; they can sometimes be rough with very little but noticeable pinckees; they have a unique odor; and they fracture fibrously. The petiole of the leaf stalk usually exhibits four different holes when sliced transversely, with big cavities in the center and little cavities on the perimeter. [30]

Fruit is a collection of immature nutlets. Avoid ripe nut-lets, which are round or oblong and up to 1.0 cm long by 1.5 cm broad. They have a firm, effortless, brown or gray black pericarp that is pedunculated, has one seed, and is somewhat longitudinally striated. The ripe carpe is filled with seeds.[19] Sepals, petals, and stamens are spirally arranged and gradually pass one into another. Solitary, large, 10–25 cm in diameter, white pink or pinkish white fragrant peduncles arising from the nodes of the rhizomes, sheathing at the base, 1-2 cm long, green or blackish green, hard and stout, smooth or rough due to the presence of numerous small scattered prickles. [13]

The rhizomes are silky horizontally streaked with brown patches, measuring 60-140 cm in length and 0.5 to 2.5 cm in diameter. They also have nodes and internodes. The color range is golden white to yellow brown. Freshly cut, it emits a mucilaginous liquid and has numerous bigger holes around by a few larger ones; the fracture is fibrous and stiff. There is a vague odor[31, 32].

Figure 1: Different parts of Nelumbo nucifera

PHYTOCHEMISTRY

I. *Flower*

The stamens of N.nucifera have been shown to contain a number of flavonoids. Kaempferol and seven of its glycosides are among them: kaempferol 3-O-β -D-galactopyranoside, kaempferol 3-O-β -D glucopyranoside, kaempferol 7-O-β -D glucopyranoside, kaempferol 3-O-a-Lrhamnopyranosyl-(1-6)-β -D-glucopyranoside, and kaempferol 3-O-a-L-rhamnopyranosyl-(1-2)Kaempferol 3-Oa-L-rhamnopyranosyl -(1-2) - β - D-glucopyranosideNelumboroside A and B, myricetin 3 0,5 0 -dimethylether 3-O- β -D-glucopyranoside, quercetin 3-O- β -D-glucopyranoside, kaempferol-3- O- β-D-glucurono-pyranoside, kaempferol 3-O-β-Dglucuronopyranosylmethylester, and quercetin 3-O-β -D-glucurono-pyranoside. Two

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 04, 2024

isorhamnetin glycosides are also present in it: isorhamnetin 3-O-β-D-glucopyranoside and isorhamnetin 3-O-a-Lrhamnopyranosyl-(1-6) -β -D-glucopyranoside. Stamen extract has also been shown to contain several non-flavonoid substances, such as adenine, myo-inositol, arbutin, and β-sitosterolglucopyranoside [33–35].

II. *Fruits and seeds*

N. nucifera seeds are high in tannin, carbohydrate, fat, protein, and asparagin. One hundred seeds weighs, on average, 87.35 g. Generally speaking, lotus seeds are high in minerals, unsaturated fatty acids, protein, and amino acids[46]. Numerous minerals, including chromium (0.0042%), sodium (1.00%), potassium (28.5%), calcium (22.10%), magnesium (9.20%), copper (0.0463%), zinc (0.0840%), manganese (0.356%), and iron (0.1990%), have also been discovered to be present in nelumbo seeds. Its energy value is 348.45 cal per 100 g. Other significant nutritional components include total ash (4.50%), moisture (10.50%), crude carbohydrate (1.93%), crude fiber (10.60%), fat (72.17%), and protein (2.70%).[36,16] Alkaloids include dauricine, lotusine, nuciferine, pronuciferine, liensinine, isoliensinine, roemerine, neferine, and armepavine are the main secondary metabolites found in the seeds. Procyanidin was extracted from N. nucifera seedpods. D(–)-3 0-bromo-O-methylarmepavine, D–1,2,3,4-tetrahydro-6-methoxy-1-(p-methoxbenzly) -2-methyl-7-isoquino- linol, saponins, and carbohydrates are also present in seeds (11, 12). Additionally, the seed polysaccharides have been identified and extracted. Seed polysaccharides are mostly made up of four types of monosaccharides: D-galactose, L arabinose, D-mannose, and Dglucose, as demonstrated by acid hydrolysis and methylation. The fruit wall and seed coat of N. nucifera are made up of a complex of polysaccharides, mostly galactose and mannose units as well as insoluble tannins, according to analysis.

After analyzing the fruit wall and seed coat of Nelumbo using Curie-point pyrolysis, gas chromatography, and mass spectrometry, several pyrolysis polysaccharide products were obtained. These included 2-furaldehyde, 2-hydroxy methyl furan, (SH)-furan-2-one, 2,3-dihydro-5-methylfuran-2-one, 2-hydroxy-3-methyl-2-cyclo penten-l-one, 5-hydroxymethyl-2-furaldehyde, anhydrosugar (levogalactosan), and 1,2benzenediol. 2-benzenediol, 4-methyl-1, 1,6-anhydro-a –D-glucopyranose, and 2,6-dimethoxy 4-ethnylphenol and 2-methoxyphenol-4-carboxy. In Indian marketplaces, the seeds are marketed as a vegetable under the name "kamalgatta."[37–40]

III. *Rhizomes*

In Asian nations, lotus rhizomes are eaten as vegetables. Their mineral richness makes them useful as health foods. There are a lot of starch granules all around the tissue. The starch content of fresh rhizome is 31.2%; it has no distinct flavor or aroma. When isolated Nelumbo starch was compared to maize and potato starch for its binding and disintegration qualities, it was discovered that Nelumbo starch performed better when used as an adjuvant for making tablets. 50% (v/v) alcohol is said to be necessary for the maximal extraction of the components. [41] Lotus rhizomes are consumed as vegetables in Asian countries. They are beneficial as health foods because of their mineral content. The tissue is covered in a large number of starch granules. Fresh rhizome has no discernible flavor or scent and contains 31.2% starch. Comparing the binding and disintegration properties of isolated Nelumbo starch to those of maize and potato starch, it was shown that Nelumbo starch performed better when utilized as an adjuvant for tablet production. It's stated that in order to extract the components to their maximum potential, 50% (v/v) alcohol is required. [41]

IV.*Leaves*

According to studies, the leaves are abundant in several different alkaloids. The primary constituents in the non-phenolic leaf extract fractions had retention data and mass spectra that were indistinguishable from those of nuciferine, roemerine, anonaine, pronuciferine, and N-nornuciferine.[4] N. nucifera leaf extract also contained two benzylisoquinoline alkaloids, (+)-1(R)-coclaurine and (–)-1(S)-norcoclaurine[21]. Two phenolic bases, armepavine and N-methyl-coclaurine, were also detected in N. nucifera leaf extract, in addition to the six non-phenolic bases that were identified: roemerine, nuciferine, ano-naine, pronuciferine, Nnornuciferine, and liriodenine. From leaves and petioles, the following compounds were isolated: dehydro-emerine, dehydronuciferine, dehydroanonaine, anonaine, N-nornuciferine, Onornuciferine, remerine, roemerine, armepavine, liensinine, negferine, asimilobine, and lirinidine. The leaves also contain a glycoside, nelumboside, and flavonoids such as quercetinand leuco-anthocyanidin which were identified as leucocyanidinand leucodelphinidin.[20] It has also been reported that the leaves contain additional flavonoids, including astragalin, rutin, (+)-catechin, hyperoside, isoquer-citri, and quercetin 3-O-a-arabinopyranosyl-(1!2)-β-galactopyranoside, as well as quercetin-3-O-β-D-glucuronide.[41–45] The leaves' chloroform extract was analyzed chemically and using scanning electron microscopy to reveal that the wax was made up of a combination of aliphatic chemicals, mostly

nonacosanol and nonacosanediols. The secondary alcohol nonacosan-10-ol (16.2% by weight) was found in substantially smaller amounts in the gas chromatography spectra of lotus leaf waxes than in nonacosanediols (64.7%). The leaf wax extracts subjected to gas chromatographic analysis produced the following results: nonacosan-10-ol (16.2 ± 1.1%), triacontan-7-ol (2.4 ± 0.4%), nonacosane-4, 10-diol (18.6 ± 0.5%), nonacosine -5, 10-diol (34.1 ± 1.9%), nonacosane-10, 13-diol (12.0 ± 0.7%), hentriacontane-12, 15-diol (1.8 ± 0.0%), tritriacontane-9, 10-diol (0.7 ± 0.0%), and octadecanoic acid (0.7 ± 0.0). [46–48]

PHYSIOLOGICAL SIGNIFICANCE

I. **Analgesic activity**

Red & white lotus seed alcohol extract works well as an analgesic. The white lotus seed, at 600 mg/kg body weight, had a greater impact than the other lotus seed extracts when compared. [49]

II. **Antipyretics**

The antipyretic effect of Nucifera stalk ethanol extract on the average body temperatures and yeast-induced pyrexia in rats was assessed. When the stalk extract was given orally at 200 and 400 mg/kg, it significantly increased activity in both animals. It was discovered that the stalk extract significantly lowered normal body temperatures up to three hours after administration at a dosage of 200 mg/kg and up to six hours after administration at a dose of 400 mg/kg. The extract demonstrated dose-dependent reduction of body temperature for up to 4 hours at both dosages in the model of yeast-induced increase of body temperature, and the outcomes were similar to those of paracetamol, a common antipyretic drug. [50]

III. Anti-inflammatory effects

At doses of 200 & 400 mg/kg, an alcohol rhizome extract prevented inflammatory responses in rats. The anti-inflammatory properties were similar to those of dexamethasone and phenylbutazone. In elderly rat gingival tissues, kaempferol, which was extracted from holy lotus, decreased the inflow of cytokines , reactive oxygen species. In mice, bleomycin-induced lung fibrosis was reduced by isoliensinine that was extracted from the seeds46. Decreased production of mediators of inflammation and antioxidant activity were linked to the protective effect. [51, 52]

IV. **Anticancer Activity.**

Both in vitro and in vivo, several extracts and isolated compounds from distinct N. nucifera components exhibit anticancer action. Isolesinine is the most effective cytotoxic of the three primary alkaloids; it mainly induces apoptosis in triple-negative breast cancer cells by activating p38 MAPK/JNK and generating reactive oxygen species (ROS). [53]

V. **Antiplatelet activity**

The white and pink N. nucifera flower hydroethanolic extracts have strong antiplatelet properties, although they are only effective against primary hemostasis in human blood. In addition to releasing cytoplasmic calcium, which in turn triggers the release of ADP63, the flavonoids in the hydroethanolic extract may have inhibited platelet adhesion and aggregation. [54]

VI. **Hypoglycemic Activity:**

Research evaluated the hypoglycemic effect of Nucifera seeds' inorganic components on rats with diabetes caused by streptozotocin. The trace elements included in seed ash may influence insulin secretion directly or indirectly, or they may work in concert to maintain normoglycemia. [55]

VII. **Cytoprotective effects**

Numerous antioxidants, including carotenoids, lipoic acid, uric acid, and others, may be present in lotus root extracts. These antioxidants may also be responsible for the extracts' ability to prevent the iron-induced cell death that has been shown in this instance.[34] As a result, it is evident that lotus root aqueous extracts can stop iron-induced oxidative damage to C6 glioma cells. Additionally, it is possible that these extracts contain one or more cytoprotective substances that can shield glial cells from the oxidative damage caused by an abnormal buildup of iron in the brain, protecting brain function, especially in the elderly.[56,9]

VIII. **Erectile Dysfunction treatment**.

The impact of extraction neferine on the baseline concentrations of cyclic guanosine monophosphate and cyclic adenosine monophosphate were examined by researchers. In the rabbit corpus cavernosum, nerferine increased the levels of cAMP in a dose-dependent manner; however, an adenylyl cyclase inhibitor had no suppressive impact on this action. Neferine boosted cAMP accumulation in a dose-dependent manner, with

prostaglandin E1 (PGE1) acting as a catalyst to promote cAMP synthesis. Sodium nitroprusside and guanylyl cyclase inhibitor had no effect on the amount of cGMP. Neferine significantly increases the quantity of cAMP in the tissue of the rabbit corpus cavernosum by inhibiting phosphodiesterase activity [57].

IX. **Antiestrogenic effect**

Because N. nucifera is antiestrogenic, giving it to female rats resulted in estrogen suppression. Since an antiestrogenic chemical lowers the moisture content of the uterus, a reduction in the weight of the ovary and uterus demonstrates the antiestrogenic character of N. nuclefera. [58]

X. **Anti-Parkinsonian Activity:**

Researchers measured a variety of behavioral and biochemical parameters in order to examine the antioxidant and anticataleptic properties of Nelumbo nucifera's methanolic seed extract, which was partitioned with chloroform and used in the rat model of haloperidol-induced catalepsy. Male albino rats were given a dose of haloperidol (1 mg/kg, i.p.) to induce catalepsy. When compared to the haloperidol-treated group, all drug-treated groups showed a substantial decrease in cataleptic ratings; the group that received Nelumbo nucifera (200 and 400 mg/kg body weight) saw the largest decrease. The brain's biochemical characteristics, such as catalase, superoxide dismutase (SOD), and thiobarbituric acid reactive substances (TBARS), were measured. The study found that when haloperidol was treated with Nelumbo nucifera, the levels of TBARS, Catalase, and SOD were recovered.

XI. **Immunomodulatory effects**

In adult periphery plasma mononuclear cells (PBMCs), an extract of ethanol from lotus seeds reduced the advancement of the cell cycle, the production of cytokine genes, and the proliferation of cells.68. The immunomodulatory activity of (S)-armepavine from sacred lotus includes the following: (1) reduction of T cell-mediated cytokine production in sera and autoantibody production; (2) suppression of cytokine mRNA levels in splenocytes; (3) enhanced kidney function with decreased glomerular hypercellularity and immune complex deposition; and (4) decreased autoantibody as well as T cell-mediated cytokine production in sera. [60]

XII. **Antiaging**.

An antiaging ingredient found in Nelumbo nucifera seed extract helps to lessen signs of aging such as elasticity loss, acne, pores, wrinkles, fine lines, blemishes, and so on. A good vehicle contains compounds with strong anti-aging properties. It encourages skin that seems younger. [61]

XIII. **Anti-allergic effects**

Key receptors were blocked and immunoglobulin E-mediated allergy responses were reduced by a stamen methanol extract containing kaempferol. [62, 63]

XIV. Diuretic activity

Researchers observed that the rhizome of N. nucifera has diuretic properties. At dosages of 300, 400, and 500 mg/kg, the rhizome's methanol extract significantly reduced the amount of water in the rats' bodies. Urine volume increased in a dose-dependent manner, and there was a notable excretion of K+ along with the elimination of Na+ and Cl-. Compared to using Furosemide (20 mg/kg), the usual diuretic, there was less of an increase in urine volume. [64]

XV. Antimicrobial activity

Significant antibacterial activities were demonstrated by several rhizome extracts against Escherichia coli, Bacillus subtilis, B. pumilis, Pseudomonus aeruginosa, and Staphylococcus aureus. Comparing the chloroform extract to the common medication chloramphenicol, it was discovered that the extract was the most effective.[14] The rhizome extract's antifungal and anti-yeast properties were assessed against five distinct strains of yeast and fungi, namely Trichophytum mentagopyhtes, Aspergillus niger, Candida albicaus, and A. fumigatus. The extract demonstrated potential activity in each strain examined, and its effects were comparable to those of griseofulvin, the drug used as a standard for comparison.[65,66]

CONCLUSIONS

There have been reports in traditional medicine that different components of N. nucifera, such as as the leaves, rhizomes, seeds, and flowers, have medicinal potential for treating a variety of ailments. Using a variety of in-vitro and in-vivo test paradigms, the pharmacological properties of various preparations of rhizomes, seeds, leaves, and flowers, as well as the chemicals extracted from these extracts, have been shown. These include actions that are immunomodulatory, anti-inflammatory, antimicrobial, anti-

arrhythmic, antipyretic, anti-ischaemic, anti-diabetic, hypoglycemic, and anti-diarrheal. The relevant bioactive molecules are classified into many chemical classes; they include triterpenoid, alkaloids, flavonoids, glycosides, vitamins, and minerals. As a result, the medicinal properties and diverse active components of N. nucifera's distinct sections are well characterized. Numerous physiological and phytochemical investigations that have shown N. nucifera's medicinal potential are highlighted in this review. In order to develop evidence-based treatments, this has to be investigated further through clinical trials on human participants.

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