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REVIEW ARTICLE

PHARMACOLOGICAL IMPORTANCE OF *NELUMBO NUCIFERA*: A REVIEW

Shailbala Singh Baghel, Seema Dubey*

Department of Chemistry, Sarojini Naidu Government Girls P.G. (Autonomous)
College, Bhopal (M.P.)

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ABSTRACT:

Nelumbo nucifera commonly known as Indian lotus has been used as a native medicine in India. The extracts of rhizomes, seeds, flowers and leaves have been reported to have varied therapeutic potential. Several bioactive compounds have been consequential from these plant parts belonging to different chemical groups, including alkaloids, flavonoids, glycosides, triterpenoid, and vitamins etc., which all have their own therapeutic impact. These days' different parts of lotus have been consumed as functional foods. Thus, lotus can be regarded as a potential nutraceutical source.

Keywords: *Nelumbo nucifera*, Bioactive, Nutraceutical.

*Correspondence for Author

Seema Dubey

Sarojini Naidu Government
Girls PG (Auto.) College,
Bhopal (M.P.)

Email:

sdubey82@yahoo.co.in

INTRODUCTION:

Nelumbo nucifera (Nymphaeaceae), a perennial aquatic plant, has been used as a medicinal herb in China and India. Different part of plant (leaves, seeds, flower, and rhizome) can be used in traditional system of medicine. In traditional system of medicine, the different parts of plant is reported to possess beneficial effects as in for the treatment of pharyngopathy, pectoralgia, spermatorrhoea, leucoderma, smallpox, dysentery, cough, haematemesis, epistaxis, haemoptysis, haematuria, metrorrhagia, hyperlipidaemia, fever, cholera,

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hepatopathy and hyperdipsia. Following the traditional claims for the use of *N. nucifera* as cure of numerous diseases considerable efforts have been made by researchers to verify its utility through scientific pharmacological screenings.¹

There are two varieties of 'kamala': one has white flowers and is commonly called 'pundarika' or 'sveta kamala'; the other has pink or reddish-pink flowers and is called 'rakta kamala'.² Virtually, all parts of the lotus plant are used: the rhizome is used as food, seed as medicine, thalamus as fruit, leaves as plate (thali), stalks as pickle, petals for colour extraction, and tender leaves as food after being blended with vegetables.³

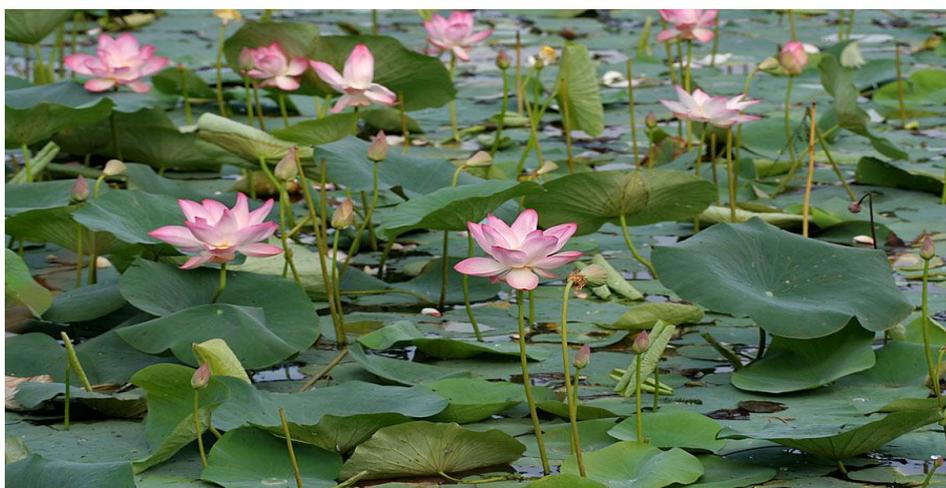


Figure: *Nelumbo nucifera*

Taxonomic Classification ⁴

Kingdom	Plantae – Plants
Sub Kingdom	Tracheobionta
Super Division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Magnoliidae
Super order	Protaenae
Order	Proteales
Family	Nymphaeaceae– Lotus Family
Genus	Nelumbo Adans – Lotus
Species	Nelumbo nucifera Gaen. – Sacred lotus.

Synonyms⁵

English – Sacred lotus

Hindi – Kanwal, Kamal

Sanskrit – Ambuja

Tamil - Ambal, Thamarai, Padma, Pankaja, Kamala

Bengal – Padma

Gujarat –Suriyakamal

Malayalam – Tamara

French –Nelumbo

German – Indische lotosblume

Persian – Nilufer.

Morphology

Leaves

Leaves are large, of both types, aerial as well as floating orbicular 20-90 cm. In diameter, abruptly acute to form a short tip, petiolate, entire glaucous, non-wettable, strong cupped in case of aerial leaves and flat in case of floating ones, radiantly nerved, the fresh leaves are leathery, but on drying they are nearly membranous and brittle, there is more or less brownish red blotching on the lower surface, petioles of the aerial leaves are erect and stout white those of the floating ones are not strong enough. The usual length varies from 24.00 to 33.00 cm. in case of aerial leaves and 23 to 30 cm in case of floating, petioles are smooth, greenish or greenish brown in colour with small brown dots sometimes rough with very small, but distinct prickles, odour is distinct, fracture is fibrous. When transversely cut, the petiole of leaf stalk always shows four distinct, large cavities in the centre and small cavities in the periphery.⁶

Fruits and Seeds

Fruit is an aggregate of indehiscent nut-lets. Ripe nutlets are ovoid, roundish or oblongish up to 1.0 cm long 1.5 cm broad, with hard smooth, brownish or greyish black pericarp which is faintly longitudinally striated, pedunculated and one seeded. Seeds fill in the ripe carpel. Fruits of *N. nucifera* have remarkable power of dormancy and indeed the proved longevity of its seeds exceeds that of any known species of flowering plant. Robert Brown, first keeper of botany in the British museum, experimented with fruits of *Nelumbo* at various times between 1843- 1845 showed that they retained the power of germination after 150 years of confinement in glass-topped box.



Figure: leaves of *Nelumbo nucifera*

Flowers

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, sepals, petals and stamens are spirally arranged passing gradually one into another.



Figure: flower of *Nelumbo nucifera*

Rhizomes

The rhizomes are 60-140 cm long 0.5 to 2.5 cm in diameter, yellowish white to yellowish brown in colour, smooth longitudinally striated with brown patches, Nodes and internodes are present. When freshly cut is exudes mucilaginous juice and show a few large cavities surrounded by several larger ones, fracture is tough and fibrous. Odour is indistinct.⁷

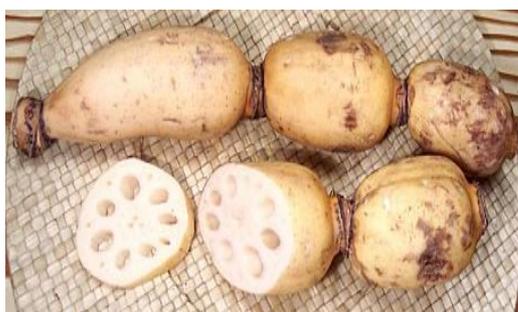


Figure: Rhizomes of *Nelumbo nucifera*

Chemical constituents

A wide variety of chemical constituents are isolated from various parts of *N. nucifera*

- **Fruits and seeds:** The seeds of *N. nucifera* are rich in asparagin, fat, protein, starch and tannin.⁸ The lotus seed is composed of three parts – integuments, plumule and cotyledons, which comprise 3.74%, 3.03% and 93.23% of the mass, respectively. The average weight of 100 seeds is 87.35 g. *Nelumbo* seeds have also been found to contain a variety of minerals such as 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%). Other relevant nutritional elements include total ash (4.50%), moisture (10.50%), crude carbohydrate (1.93%), crude fibre (10.60%), fat (72.17%), and protein (2.70%); its energy value is 348.45 cal per 100 g.⁹ The seed polysaccharides have also been isolated and characterized. Acid hydrolysis and methylation showed that seed polysaccharides are mainly composed of four types of monosaccharide: D-galactose, L arabinose, D-mannose and D-glucose.¹⁰
- **Leaves:** Combined gas/liquid chromatography–mass spectroscopy has shown that the leaves are rich in a number of alkaloids. In the analysis of non-phenolic fractions of the leaf extract the major components had retention data and mass spectra identical to those of

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nuciferine, roemerine, anonaine (14), pronuciferine and N-nornuciferine (15). Two benzylisoquinoline alkaloids, (+)-1(R)-coclaurine (16) and (-)-1(S)-norcoclaurine (17), were also found in leaf extract of *N. nucifera* (Mukherjee PK *et al.*, 1996). The leaves also contain a glycoside, nelumboside (28), and flavonoids such as quercetin (29) and leucoanthocyanidin which were identified as leucocyanidin (30) and leucodelphinidin (31)[37,42]. The presence of some other flavonoids in the leaves such as quercetin 3-O-a-arabinopyranosyl-(1'2)- β -galactopyranoside, quercetin-3-O- β -D-glucuronide (32), rutin (33),(+)-catechin (34),hyperoside (35), isoquer-citri (36) and astragalin (37) has also been reported.^{11,12}

- **Flower:** Several flavonoids have been identified in the stamens of *N.nucifera* (Figure 3). These include kaempferol (38) and seven of its glycosides: kaempferol 3-O- β -D-galactopyranoside (39), kaempferol 3-O- β -D-glucopyranoside (40), kaempferol 7-O- β -D-glucopyranoside (41), kaempferol 3-O-a-L-rhamnopyranosyl-(1-6)- β -D-glucopyranoside (42), kaempferol 3-O-a-L-rhamnopyranosyl-(1-2)- β -D-glucopyranoside (43), kaempferol 3-Oa-L-rhamnopyranosyl -(1-2)- β - D-glucurono-pyranoside (44), kaempferol-3- O- β - D-glucurono-pyranoside (45), kaempferol 3-O- β -D-glucuronopyranosyl methylester (46), myricetin 3 0 ,5 0 -dimethylether 3-O- β -D-glucopyranoside (47), quercetin 3-O- β -D-glucopyranoside (48), nelumboside A (49) and nelumboside B (50). It also contains two isorhamnetin glycosides: isorhamnetin 3-O- β -D-glucopyranoside (51) and isorhamnetin 3-O-a-L-rhamnopyranosyl- (1 \rightarrow 6) - β -D-gluco- pyranoside (52).^{13,14}
- **Rhizomes:** The rhizomes of lotus are consumed as a vegetable in Asian countries. They are used as health foods because of their mineral content. Abundant starch grains are present throughout the tissue. Fresh rhizome contains 31.2% starch, which shows no characteristic taste or odour. The binding and disintegration properties of isolated *Nelumbo* starch have been compared with maize and potato starch; *Nelumbo* starch was found to be superior as an adjuvant in the preparation of tablets. It has been reported that 50% (v/v) alcohol is required for maximum extraction of the constituents.¹⁵

Cultivation

The sacred lotus can be propagated from seed. The long-lived seeds have extremely hard coats, one end of which must be filed away to representation the endosperm before germination. The

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seedling will then begin to appear 24 hours later when placed at 25-30°C. The seedlings involve high light levels in order to form a tuber that is large sufficient to endure its first winter.

Propagation can also be carried out by separation in late winter, just before the growing season. This hard task is carried out during re-potting, when the plants are dormant. After a mounting season it can be probable to find several tubers in a large pot. The growing tips must not be damaged, so the dung should be washed away cautiously and the growing tips located. The material for propagation should consist of a growing tip, behind which there is a constricted area, followed by a tuber and another constricted region followed by a tuber and finally a different thin area with a tuber behind, throughout which the cut can be made. This material, looking like two and a half sausages, can be placed in an individual pot.

The propagation material should be enclosed with at least 10 cm of soil (loam), and placed in a position that will avoid damage to the growing tip from contact with the pot side. A gap of at least 15 cm should be left above the soil at the top of the pot. This gap allows space for a tank of water if the pot is taken out of the pool, and prevents the rhizome from coming out of the pot when the pot is in a pond.

Both division and seed sowing have productively produced new sacred lotus plants at Kew. The mature plants are kept in round 50-litre pots, without any drainage holes, because drainage holes or the corners of square pots could trap the growing tips. It is possible to move these watertight pots between Kew's display houses and the Tropical Nursery for overwintering. The plants are kept under water at all times, at a depth of 10-30 cm.

Medicinal Uses of Lotus Seed and other Lotus Plant Parts

Lotus seeds are classified as astringents, being sweet and neutral, and benefiting the spleen, kidney, and heart. The sweet taste and nourishing qualities of the seed are responsible for the benefit to the spleen; this helps stop diarrhea associated with qi deficiency. The astringent quality helps prevent loss of kidney essence, so the seeds are used to treat weak sexual function in men and leukorrhea in women. The seed also has calming properties that alleviate restlessness, palpitations, and insomnia (more so in the whole seed with embryo). The medicinal dosage is 6-15 grams when it is combined with other herbs that have similar applications and double that when used as the main ingredient (the amount in the bean and

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lotus soup is about 7 grams per serving and in the cream lotus soup and sweet lotus desert about 37-40 grams per serving).

- As an example of a therapy for diarrhea, one ounce of lotus seed is soaked in warm water for a few hours, then an adequate amount of rock sugar is added (to taste), and the mixture is simmered until the lotus seeds are well done. To this thick soup a cup of tea-made by steeping 5 g of black tea in boiling water-is added to yield the medicinal food. Traditional herb formulas for diarrhea are described in the next section.
- Inside the seed there is a green embryo that is quite bitter; it is usually removed before the seed is provided as a food product. The embryo (*lianxixin*; heart of the lotus seed), is classified as bitter and cold and benefiting the heart; it dispels pathogenic heat from the heart to treat fidgets and spontaneous bleeding due to heat. The bitter components are isoquinoline alkaloids with sedative and antispasmodic effects. The alkaloids dilate blood vessels and thereby reduce blood pressure. Small amounts of the alkaloids are found in the seeds with embryo removed, and these may contribute an antispasmodic action for the intestines, helping to alleviate diarrhea.
- The lotus leaves (*heye*) are also bitter, but neutral, and are said to benefit the stomach, spleen, and liver. They are used for treatment of summer heat syndrome and dampness accumulation; they also contain the lotus alkaloids with hypotensive effect. Lotus leaf has become popular for lowering blood lipids and treating fatty liver; it is commonly combined with crataegus, which promotes blood circulation and lowers blood fats, for that purpose. Lotus stems (*hegeng*) are used medicinally in the same way as the leaves for treatment of summer heat and are used also to treat tightness in the chest due to obstruction of qi circulation.
- Lotus stamen (*lianxu*) is sweet, astringent, and neutral, benefiting the heart and kidney; it is mainly used for preventing discharge, such as treatment of leukorrhea or for frequent urination. It contains flavonoids and a small amount of alkaloids. Lotus nodes, the rhizome nodes (*oujie*), are astringent and neutral, benefiting the liver, lung, and stomach. They are mostly used to control bleeding. All the parts of the lotus have some antihemorrhagic effect, but the rhizome nodes are relied upon for that purpose specifically. The active component for reducing bleeding is not yet established, though quercetin and other flavonoids may play a role by improving capillary wall strength. By charcoaling the lotus plant parts, as is

sometimes done, a hemostatic effect is assured, as charcoal itself has this effect (it promotes blood coagulation).

- **Traditional Medicine and Pharmacological Activities**

Lotus is used in traditional medicine by people for its tremendous health benefits in many parts of the world. It is used to treat sunstroke, diarrhea, dysentery, hemorrhoids, dizziness, vomiting of blood, uterine bleeding disorders, promoting conception, improving the skin condition, controlling burning sensation, against infections, cough, hypertension, fever, urinary problems, hematemesis, epistaxis, hemoptysis, hematuria, and metrorrhagia etc.^{16,17} Many pharmacological studies on lotus have proven its antidiarrheal, antiinflammatory, antipyretic, hypoglycemic, immunomodulatory, psychopharmacological, antioxidant, aphrodisiac, lipolytic, antiviral, anticancer and hepatoprotective activities.

Leaves

In traditional medicine, lotus leaves are used against diarrhea, high fever, hemorrhoids, leprosy.¹⁸ Weakness, skin inflammation, and body heat imbalance, hematemesis, epistaxis, hemoptysis, hematuria, and metrorrhagia. Lotus leaves have been reported to have lipolytic, anti-obesity, cardiovascular and hypocholesterolaemic activity.^{19,20} The leaf extract has been reported to have analgesic, anthelmintic, antiobesity and hypolipidemic activity. Lotus liquor made of blossoms and leaves has been reported to possess antioxidant activities and is effective for reducing oxidative stress.

Rhizome

Lotus rhizome and its extracts have shown diuretic, psychopharmacological, anti-diabetic, anti-obesity, hypoglycemic, antipyretic and antioxidant activities.²¹ The antioxidant property of rhizome knot extracts has been reported to be higher than those from the whole rhizome.²²

Flowers

Lotus flowers, floral parts or their extracts have also been used against many diseases like hypertension, cancer, weakness, and body heat imbalance, consolidation of kidney function, male sexual disorders, syphilis, stopping bleeding and to eliminate the stagnated blood. Flowers, with their parts or extracts have shown to possess antimicrobial activities vasodilating effects, antihypertensive and antiarrhythmic abilities, aphrodisiac activity antioxidant and free radical scavenging capacity.^{23,24}

Seeds

In traditional medicine Lotus seeds are used as spleen tonic and seed powder is used against cough. Plumule from the ripe seed is used for the treatment of many diseases, including nervous disorders, insomnia, high fevers with restlessness and hypertension. The seeds or their extracts have been reported to possess anti-proliferative anti-fibrosis, antidepressant, anti-inflammation, astringent hepatoprotective and free radical scavenging, anti-obesity and hypolipidemic effects anti-inflammatory immunomodulatory and antiviral activities.^{25,26}

Conclusion

India is a country where lotus can be found abundantly in wetlands, ponds, lakes, canals etc. Different parts of *N. nucifera*, including the leaves, rhizomes, seeds and flowers, have been reported to have therapeutic potential in traditional medicine for the treatment of various diseases. The pharmacological studies have shown tremendous potential of the plant against a wide range of diseases and infections.

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