

## **A REVIEW ON GENUS NYMPHAEA: MULTI-POTENTIAL MEDICINAL PLANT**

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Received 01 Sep 2017; Revised 12 Sep 2017; Accepted 13 Sep 2017, Available online 15 Oct 2017

### **Abstract**

Natural products, such as plants extract, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug discoveries because of the unmatched availability of chemical diversity. In the last few decades there has been an increasing interest in the study of medicinal plants, as knowledge on ethnopharmacology, its holistic system approach, supported by the experiential base, can serve as an innovative and powerful discovery engine for newer, safer, and affordable medicines. This review is an attempt to assess the available scattered literatures and compile them under different categories in a systematic way, to provide the pharmaceutical prospective of genus *Nymphaea*. It is expected that many novelties will rapidly enlarge the current knowledge about genus *Nymphaea*, their constituents and corresponding pharmacological effects.

**Keywords:** *Nymphaea*, Pharmacological, Importance.

### **INTRODUCTION**

Herbs are staging a comeback and herbal 'renaissance' is happening all over the globe. The herbal products today symbolise safety in contrast to the synthetics that are regarded as unsafe to human and environment. In spite of the overwhelming influences and our dependence on modern medicine and tremendous advances in synthetic drugs, a large segment of the world population still likes drugs from plants. In many of the developing countries the use of plant drugs is increasing because modern life saving drugs are beyond the reach of three quarters of the third world's population although many such countries spend 40-50% of their total wealth on drugs and health care. As a part of the strategy to reduce the financial burden on developing countries, it is obvious that an increased use of plant drugs will be followed in the future.<sup>1</sup>

The aquatic plant water lily is regarded as the queen of Indian flowers, beloved of the poets. The species belong to *Nymphaea* are prized as ornamentals, being considered as a religious plant and also have been introduced and naturalized outside of their active habitats. *Nymphaea* occur almost worldwide, comprising 45-50 species.

Water lily is known as 'Bunga Teratai' for Malays, 'Kumuda' for Indians, and 'Shuey lien' for Chinese. Water lily can be defined as primitive flowering plants with large rhizomes. There are approximately 70

species and 6 genera worldwide.<sup>2</sup> The genera are *Euryale*, *Victoria*, *Ondinea*, *Barclaya*, *Nuphar*, and *Nymphaea*. Genera *Nymphaea* and *Nuphar* are the most common in Malaysia.

*Nymphaea nouchali* is used as an ornamental plant because of its spectacular flowers. Sometimes this water lily is often referred as “blue lotus of India”, but it is not a lotus.<sup>3,4</sup> It is native to southern and eastern parts of Asia and is the national flower of Sri Lanka and Bangladesh. Widely distributed in India; common and locally dominant in permanent and temporary water. *Nymphaea nouchalli*, often known by its synonym *Nymphaea stellata*, or by common names blue lotus is a perennial aquatic herb.

### **History**

The name of genus *Nymphaea* is direct translation of Greek word which is related with the early Greeks practice. Water lily seeds and tubers are consumed as food many years ago by Europeans, Asians and Africans during emergency time. The Egyptians always admire and eat *Nymphaea nouchali* and *Nymphaea lotus*. The rhizome, flowers, and leaves are eaten by the Egyptian while the buds are frequently portrayed on ancient monuments, furniture and murals. Water lilies are also used in religious ceremony during Egyptian civilization. Furthermore, the Egyptian royal family believes that the beautiful blooms of water lily portray purity and immortality. In the early 18th century, the South African citizens ate the rootstock of blue water lily either raw or in curry dishes. The water lily is also symbolism for certain countries. White water lily becomes the national flower in Bangladesh and state flower in Andhra Pradesh, India while blue water lily becomes national flower in Sri Lanka. Water lily is a symbolic character for someone born in July.

### **Habitat and distribution**

Water lily was first discovered in the early cretaceous era in Portugal. Genus *Nuphar* is distributed in temperate regions of North America from Alaska to Newfoundland south to northeastern Mexico. *Euryale ferox* is native to Asian countries namely China, India and Japan. Genus *Nymphaea* can be found in Malaysia as its distribution is throughout North America, Africa, Europe and Asia. *Nymphaea nouchali* has been cultivated in Southeast Asia for centuries, especially around temples. It is also cultivated in Sri Lanka and gathered from dried ponds in India for the rhizomes, which are used as food and animal fodder as a source of starch. In Ayurvedic medicine, it is used to treat indigestion.

Cultivars include *Nymphaea nouchalivar. cyanea*, which has medium-sized pale to deep blue flowers and *Nymphaea nouchali var. versicolor*, which is commonly exported in the form of tubers from Sri Lanka to Europe and the U.S. for use in the aquariums; the tubers grow quickly after exposure to warm water, making an “instant” aquarium plant.

## General description

The Nymphaeaceae have large, thick and black rhizome since it does not have any true stems. The leaves grow directly from the rhizome. The structures of the leaf are large and flat, rounded or oval in shape. They may be also alternate, floating, pinnately veined, long-petiolate or cordate. The leaves play important role in order to maintain the buoyancy of the plant as its margin slightly rolled inwards toward the topmost side. Moreover, the underneath of the leaves is constantly wet which can hold the structure against the water. Besides that, the leaf can either submerged, or floating on water surface. Nymphaeaceae has notable characters which are the presence of large flowers, numerous ovules in each carpel, the stem is not free floating and the leaves are attached with rhizome. The flowers of water lily are large in size and may be axillary or solitary. The flowers grow on the tips of stalks with 4-5 sepals, many petals, many stamens and few pistils. The numerous laminar stamens will surround the pistils at the centre of the flower. It is bisexual plant since the flowers have both pistils and stamen in same plants. The flower bloom early in morning and close entirely in late afternoon. It will stay closed during night. The flower has a sweet fragrant which can attract insects to visit. The fruits of water lily are dicotyledon with has berry-like structure and spongy. The seed will either have aril or without aril.

## Traditional uses

The powdered root stock is given for dyspepsia, diarrhea, piles and urinary ailments. A decoction of the flower is given for palpitation of the heart. It is also supposed to be a blood purifier and aphrodisiac. The rhizome is prescribed for cystitis, nephritis, enteritis, fevers and insomnia.<sup>5</sup> The whole plant is being used for the treatment of diabetes and eye disorder. In Africa, the different species of *Nymphaea* is being used in the management of cancer.<sup>6</sup>

Rhizome along with roots of *Lawsonia inermis* grinded in rice washed water is taken to cure diabetes. Flowers are soaked in water overnight; decanted water is drunk for various cardiac problems. Seed decoction soaked in cloth is applied for the treatment of skin infection. Raw rhizome is the best medicine for dysentery.<sup>7</sup>

## Medicinal uses

*Nymphaea nouchalli* is considered a medicinal plant in Indian Ayurvedic and Siddha systems of medicine under the name Ambal. Not only is that it most commonly used for the traditional and cultural festivals in Sri Lanka. It was mainly used to treat indigestion. The rhizome is considered demulcent and used for dysentery and dyspepsia. Flowers are astringent and cardiogenic. Seeds are used as a cooling medicine in

cutaneous diseases. Like all waterlilies or lotuses, its tubers and rhizomes can be used as food items; they are eaten usually boiled or roasted. In the case of *Nymphaea nouchalli*, its tender leaves and flower peduncles are also valued as food. The dried plant is collected from ponds, tanks and marshes during the dry season and used in India as animal forage. It is used as medicines for the treatment of diabetes, inflammation, liver disorders, urinary disorders, menorrhagia, blenorragia, menstruation problem, as an aphrodisiac and as a bitter tonic.<sup>8</sup> Its hepatoprotective, anti-inflammatory and particularly antidiabetic activity has been confirmed using modern methods. Nymphayol, a steroid isolated from the flowers has been scientifically proved to be responsible for the traditionally claimed antidiabetic activity; it reverses the damaged endocrine tissue and stimulates secretion of insulin in the  $\beta$ -cells. To date sterols, alkaloids, saponins, tannins and flavonoids are reported from different parts. Recently, nymphasterol, a new steroid has been isolated and identified from the seeds.<sup>9</sup>

### **Phytochemistry**

The different classes of phytomolecules such as alkaloids, glycosides, flavonoids glycosides, hydrolysable tannins, lignans, phytosterols and triterpene saponins are found to be present in the various species of the genus *Nymphaea*. Different phytochemical constituents present in *Nymphaea*. The alkaloids such as nupharidin and apomorphine based compounds were reported from the flowers.<sup>10</sup> Nupharin and nymphaein were reported from the flowers.<sup>11</sup> Two phenolic base alkaloids coclaurine reported from the aerial parts of *Nymphaea stellata*.<sup>12</sup> The cardiac glycoside nymphalin is reported from the alcoholic flower extract.<sup>11</sup> The flavonoids such as anthocyanins, flavonols and flavones were reported and present as flavonoid glycoside with various glycone moiety among the various species of the genus *Nymphaea*.

Nymphayol (25,26-dinorcholest-5-en-3 $\beta$ -ol), a new sterol has been isolated from the successive chloroform extract of the flower. Protein, pentosan, mucilage, and tannins are reported in the seeds. Astragalin, corilagin, gallic acid, gallic acid methyl ester, isokaempferide, kaempferol, quercetin-3-methyl ether, quercetin, 2,3,4,6-tetra-*o*-galloyl dextroglucose, and 3-*o*-methylquercetin-3'-*o*-beta dextroxylopyranoside have been identified in the flowers. The HPTLC method for quantitative determination of gallic acid from hydroalcoholic dried flower extract has been reported. The leaves and shoots of *Nymphaea nouchalli* (Red water lily) have been studied for their chemical composition. The proximate analysis showed dry matter -8.4%, crude protein-16.8, ash-18.7, crude fat-2.8, crude fiber-26.3, and nitrogen free extract-35.4 for *N. nouchalli*. Mineral content showed sodium-1.19, potassium-2.23, calcium-0.52, phosphorus-0.32, and calcium / phosphorus ratio 1.63 for *Nymphaea nouchalli*.<sup>13</sup>

## Pharmacology

Anitha et al., (2012)<sup>14</sup> evaluated the safety of pet ether extract of *Nymphaea nouchali* (PNN) whole plant by determining its potential toxicity after acute and chronic administration in rats. Study on acute toxicity of extract found to be safe at the doses 2000mg/kg body weight orally as per OECD guidelines No.423. General behavior adverse effects and mortality were determined for up to 14 days. In the chronic toxicity study, the PNN was administered orally at doses of 100, 200 and 400 mg/kg once in a week for 6 weeks to rats. Biochemical and hematological parameters were determined after 6 weeks. In the acute study in rats, there was no toxicity/ death was observed at the dose of 2000mg/kg b.w. The onset of toxicity and signs of toxicity also not there. In the chronic toxicity study, no significant treatment-related changes in the levels of haematological, hepatic and renal parameters such as SGOT, SGPT, cholesterol, creatinine, urea, uric acid, protein and glucose, and serum ALP activities were observed at the termination of the study.

Sikder et al., (2012)<sup>15</sup> Different extractives of petals of *Nymphaea nouchali* were evaluated for membrane stabilizing, antioxidant, cytotoxic and antimicrobial activities. The membrane stabilizing activity was assessed by hypotonic solution and heat induced methods. In the present studies, the aqueous soluble (AQSF) materials of the petals demonstrated strong membrane stabilizing activity, whereas the chloroform (CSF) and petroleum ether soluble fractions (PESF) revealed moderate membrane stabilizing activity in both methods. The total phenolic content was also determined and expressed in gallic acid equivalent. In brine shrimp bioassay, the extractives of *N. nouchali* exhibit no lethality as evident from no death of nauplii after 24 hours of observation. On the other hand, the chloroform (CSF) and aqueous soluble fractions (AQSF) of methanol extract revealed significant antibacterial and antifungal activities against some microorganisms used in the screening.

Parimala and Shoba, (2014)<sup>16</sup> investigated the antihyperglycaemic activity of hydroalcohol extract of *Nymphaea nouchali* seeds (NN) in streptozotocin (STZ) – induced diabetic rats. Oral administration of NN extract showed significant restoration of blood glucose level to normal. After 21 days of treatment, level of blood glucose, lipid profile (total cholesterol, triglyceride), hepatic and renal markers (SGOT, SGPT, gGT, ALP, bilirubin, creatinine and BUN) significantly decreased when compared with the diabetic control. Concurrent histopathological studies of the heart and liver revealed normal histological pattern in the normal and extract-treated groups.

Bhaskara et al., (2014)<sup>17</sup> examined *Nymphaea nouchali* leaves for phytochemical profile, in vitro antioxidant and hemolytic activities. The bioactive extract exhibited the presence of carbohydrates, phenolic compounds, alkaloids and tannins. The extract showed potent reducing power and total

antioxidant activities, while it has also shown 94% of DPPH radical scavenging activity and 88% of metal chelating activity with IC<sub>50</sub> values of 42µg/mL and 28µg/mL respectively. The extract did not show harmful effect towards human erythrocytes through the test performed.

Anisha Noor et al., (2013)<sup>18</sup> prepared ethanol and chloroform extracts of *Nymphaea nouchali* leaves were investigated to evaluate their antioxidant property. The experimental data of all the tests extracts reveal that although there are small differences among the values of total phenol content, total flavonoid content, total antioxidant capacity and DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity; but both of the ethanolic and chloroformic extracts possess strong antioxidant activity.

Punjabiet al., (2014)<sup>19</sup> These crude extracts were tested for antibacterial activity by agar streak method, the extracts found to be active were subjected to Minimum inhibitory concentration (MIC) determination by TTC assay, the extracts were prepared according to the MIC and antibacterial susceptibility test was carried out using Agar well diffusion method. All the extracts showed antibacterial activity against the tested strains. But the polar extracts showed a greater antibacterial potential as compared to the non polar extracts. Methanolic extract was the most active. The highest activity was seen against *Salmonella paratyphi A* and the lowest activity was seen against *Salmonella paratyphi B*. The present study showed the effectiveness of the crude plant extract against the tested bacterial strains and indicates the potential use of the extract as antimicrobial agent for the control of infectious diseases.

Sarwar et al., (2016)<sup>20</sup> evaluated the antinociceptive and neuropharmacological activities of methanol extract of *Nymphaea nouchali* (*Nymphaeaceae*) flower (MENN). The antinociceptive activity of MENN was evaluated by heat induced (tail immersion test) and chemical induced pain models (acetic acid-induced writhing). The effect of MENN on central nervous system (CNS) was studied using hole cross test, open field test. MENN showed strong, significant and dose-dependent antinociceptive activity in both acetic acid-induced writhing and tail immersion test at all experimental doses (200mg/kg and 400mg/kg). Acetic acid induced writhing test revealed that the extract at the lower dose inhibited 59.97% and at the higher dose produced a maximum of 64.75% inhibition of writhing that is comparable to the reference drug Diclofenac Sodium. MENN also showed reduced locomotor activity in both hole cross and both open field tests. So, it is evident that MENN possesses strong antinociceptive activity as well as CNS depressant activity.

Dash et al., (2013)<sup>21</sup> methanol extract possessed better antibacterial activity against two pathogenic bacteria, *B. subtilis* (FO 3026) and *S. lutea* (IFO 3232) than commercial antibiotic nalidixic acid. Acetone extract showed moderate sensitivity whereas *B. subtilis* (FO 3026), *S. lutea* (IFO 3232) and *X. campestris*

(IAM 1671) showed resistance to ethyl acetate and petroleum spirit extracts. The minimum inhibitory concentrations of various extracts were ranged between 128–2048 µgml<sup>-1</sup>.

Parimala et al., (2015)<sup>22</sup> prepared hydroalcoholic extract of *N. nouchali* seeds has been demonstrated to possess anti-hyperglycemic effects in diabetic rats, but the functional mechanism remains unknown. The nuclear receptor, peroxisome proliferator-activated receptor gamma (PPAR $\gamma$ ) is noted to play an important role in glucose and lipid homeostasis. This study was hence focused in evaluating the effect of the extract on PPAR $\gamma$  activation, adipocyte differentiation, and glucose consumption in 3T3-L1 cells. Cell viability was assessed by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT), followed by adipogenesis assay using Oil Red O technique. Glucose consumption of preadipocytes and adipocytes in the presence of the extract was also determined. Real-time polymerase chain reaction was performed to identify the expression of genes involved in glucose consumption in the adipocytes. MTT assay confirmed the extract to be nontoxic, and Oil Red O staining confirmed enhanced adipocyte differentiation of 3T3-L1 cells in a dose-dependent manner. The extract also increased the expression of PPAR $\gamma$  target gene, which in turn enhanced the expression of GLUT-4. The data, therefore, suggests that *N. nouchali* seed extract promotes adipocyte differentiation and glucose consumption by inducing PPAR $\gamma$  activation, which in turn increases mRNA GLUT-4 expression and subsequently enhances insulin-responsiveness in insulin target tissues.

### **Miscellaneous uses**

Nymphaeaceae is important in both aspects of ecology and economy. Water lily family serves as good habitat for aquatic organisms such as fish, crabs, and others. The blooming flowers will attract insects to pollinate them while frogs favour to inhabit on water lily pads and wait for their prey. Besides that, the presence of water lily in the pond or lake could control the growth of algae in the pond as their leaves block the penetration of sunlight. These plants also become food source for other organisms as well as humans. For instance, water lily plant which is rich in carbohydrates is eaten by moose and beavers. Therefore, water lily is important to ensure the flow of energy throughout the ecosystem. Besides animals, humans also consume the carbohydrate-rich rootstalk which had been practiced by the First Nations people. Water lily is able to absorb nutrients from the water environment which then can keep clear and clean water. Moreover, they supply oxygen to the aquatic organism. In terms of socio economic values, water lilies are eaten by Asians and Native American especially the shoots and leaves. For instance, in Asian country, seed, fruit and rhizomes of *Euryale* sp. provide food to the locals. This plant family can also be made as ornamentals. Since water lily is easy to grow, it has been a popular water garden plant. Moreover, the attractive colour variation of water lily enhances the beauty of the pond. Water lily could also be used as traditional medicine. For instance, the root tea from *Nymphaea odorata* is used to treat

diarrhea, sores, sore throats and rash. White water lily can be used to decrease the effect of carcinogens and destroy the development of bacteria and other microorganisms.

### Conclusion

Natural products, such as plants extract, either as pure compounds or as standardized extracts, provide unlimited opportunities for new drug discoveries because of the unmatched availability of chemical diversity. The perception on the plant showed the presence of wide range of primary and secondary phytomolecules. The unique and novel phytomolecules present in the genus *Nymphaea* are the key to unlock the folklore claims of the various species in *Nymphaea*. The scientific research today focuses on the discovery of novel and unique molecules and on revealing unknown targets of lead molecule in nature. Water lilies and are distributed in tropical areas around the world, found on the banks of ponds lakes and rivers. Ancient rituals in Maya and Egyptian civilizations used of the flowers of *Nymphaea* (*Nymphaeaceae*). The lotus plant *Nelumbo nucifera* and *Nymphaea caerulea*, have been used by cultures, both past and present, for their medicinal properties. This review on the genus *Nymphaea* gives a detailed account of updated information on the botanical description, phylogenetic studies, geographical distribution, ethnopharmacology, and more about the phytochemical and pharmacological aspects.

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