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Lotus (National Flower of India): A review on floral biology, ornamental, nutritional and medicinal importance

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Abstract

The national flower of our country [*Nelumbo nucifera*, (2n = 16)] should tie in with the culture, history and heritage of a nation. There are two species in lotus - *Nelumbo nucifera* and *Nelumbo lutea*. The alkaloids of lotus embryos were found to possess hypotensive effects. The plant parts of lotus are edible and are used as food sources. They are the natural bioactive compounds found in plants, which are solely responsible for their medicinal activity. The secondary metabolites viz., alkaloids, steroids, tannins, cardiac glycosides, flavonoids, etc. play a major role against various activities. In the traditional system of medicine, the different parts of the plant are reported to possess beneficial effects for the treatment of common infections, skin, respiratory and reproductive diseases. Hence, it is considered as an ornamental and medicinal plant for the current era. Here, we comprehensively reviewed floral biology, medicinal, nutritional, ornamental importance and so on. This will kindle the interest of the researchers to take up studies on pharmaceutical aspects.

Keywords: lotus, botany, phytochemicals, traditional uses

Introduction

Nelumbo nucifera, (2n = 16) commonly known as lotus or sacred lotus is an aquatic perennial plant belonging to family *Nelumbonaceae*. The national flower of a country should tie in with the culture, history and heritage of a nation. It is meant to reinforce the country's image to the world and play a part in upholding the qualities that the nation holds true. The national flower of India is Lotus. It is a large aquatic herb with stout creeping yellowish white colored rhizomes and is of perennial in nature. Ancient medical literature assigned the Sanskrit name "Kamala" to *Nelumbo nucifera*, there are two forms-one with white flowers commonly called "Pundarika" or "sveta kamala" and the other with pink or reddish pink flowers called "Rakta Kamala" (Chopra *et al.*, 1958) [20].

Every part of the plant has distinct name and almost all parts are used medicinally supplying one or more drugs, the whole plant with flowers is known as "Padmini", the rhizome is known as "Kamalakand", the tender leaves as "Sambartika", the peduncle as "mrinal" or "Visa", the stamens as "Kirijalaka", the torus as "Padmakosa", the seeds as "Karnika" or "Padmaksya" and the honey formed in the flowers by the bees feeding upon padma is known as "Makaranda" or "Padma- Madhu" (Anon., 1982) [5].

It is native of China, Japan and India. It is commonly found growing in pond and is often cultivated for its elegant, sweet-scented flowers which are called as the "National flower of India". It symbolizes purity, beauty, majesty, grace, fertility, serenity, wealth, richness and knowledge. It is widely distributed in South-East Asia. In India, it is found to occur from Kashmir in North to Kanyakumari in South, showing high phenotypic diversity with different shapes, sizes and shades of pink and white flowers with petal numbers ranging from 16-160, according to Sharma and Goel (2000) [87].

Lotus is cultivated in China and Japan. In terraced fields, it is cultivated for its edible rhizomes and seeds (Anon., 1966) [4]. It is known by numerous common names including Indian lotus, sacred lotus, bean of India or simply lotus. The Linnaean binomial *Nelumbo nucifera* Gaertn is the currently recognized name for this species, which has been classified under the former names, *Nelumbium speciosum* (Wild) & *Nymphaea nelumbo*, among others (Anon., 1966) [4].

Species and Varieties

There are two species in lotus -*Nelumbo nucifera* and *Nelumbo lutea*. The commonly grown lotus species is *Nelumbo nucifera*. Usually, three varieties of lotus flowers are found in India, based on petal colour, such as white, reddish-white and reddish. Reddish-white flowers are more in demand compared to the other two varieties. White flowers are used for the preparation of garlands. The reddish variety is of low yield as compared to the other two and that is why farmers usually do not cultivate it. There are two types of flowers, namely double flowers and single flowers: double flowers have 100–150 petals per flower, whereas single flowers have 25–50 petals per flower. The three varieties of lotus found to contain both single and double flowers. (Mandal and Bar, 2013) [61].

Botany and chemical constituents in lotus

Lotus 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, radiately nerved, the fresh leaves are leathery, but on drying they are nearly membranous and brittle, brownish red blotching on the lower surface, petioles of the aerial leaves are erect and stout while 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 color 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 (Anon., 1982) [5].

Two serotonin antagonistic alkaloids were isolated from leaves of lotus are asimilobine and lirinidine. One more alkaloid nelumbine was also reported to be present in leaves and petioles of the plant which acts as a cardiac poison (Anon., 1966) [4]. The leaves also contain nelumboside, a glycoside which on hydrolysis with 5% H₂SO₄ gave one molecule of quercetin, glucose and glucuronic acid. On methylation with CH₂ N₂ followed by hydrolysis this glycoside gave “5, 7, 3, 4 tetra-ortho-methyl quercetin” m.p 192°C (Nakaoki, 1962). The leaves also contain iso-quercetin, and leucoanthocyanidin which were identified as leucocyanidin and leucodelphinidin by conversion into corresponding anthocyanidin chlorides or by paper chromatography or by absorption maxima (Nagarajan *et al.*, 1966) [73].

Lotus flowers

Lotus flowers are 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 (Gupta and Ahluwalia, 1979) [33].

The ether and aqueous of the petals, stamens and torus of *Nelumbo speciosum* lotus gave typical color reactions for flavanoids, the concentrate from the ether extract on ascending and descending paper chromatography showed the presence of quercetin and luteo (confirmed by column

chromatography) in the case of petals and stamens, only quercetin was present in torus, the aqueous extract on further concentration showed the presence of iso-quercetin and glucoluteolin in the case of petals and stamens while the torus contain only iso quercetin. The sugar was identified in each case as glucose only by paper chromatography and the osazone (Nagarajan *et al.*, 1966) [73]. The flowers also contain a glycoside kaempferol (kaempferol- 3- galacto-rahmno glycoside), (Nagarajan *et al.*, 1965) [71]. The flowers has cooling effect, used as astringent in diarrhea, also in cholera, in fever and diseases of liver, recommended as a cardiac tonic (Chopra *et al.*, 1956) [19].

The flowers of lotus are used for ornament and as offerings in temples, they are used as a source of perfume. The honey from lotus flowers is reported to possess tonic properties and considered useful for affections of the eye. Garlands made from the beautiful, fragrant white or rose flowers are used for decoration and in the worship of goddess lakshmi, the symbol of wealth (Anon, 1966) [4].

Floral biology

The flowers are solitary at the ends of long stems, each with four sepals and numerous petals and stamens. They are large, 15-25 cm across, very showy, variously coloured in shades of pink, and are followed by a somewhat cone-shaped torus, 5-10 cm in diameter, with 10-30 carpels sunk into the upper surface. These carpels mature into ovoid nut-like, edible achenes. The flowers are the key focus of the plant, and are large and showy, predominantly pink or white in color. The cone shaped central female reproductive structure is termed as thalamus which is framed by the delicate petals. The lotus bud resembles the shape of a tear-drop with pointy tip and tightly packed petals. The petals are translucent and open in overlapping spiral pattern. The flowers open in the morning and bloom for three days. The petals close after sunset trapping in the pollinating agents. The central yellow receptacle of the spongy thalamus contains the ovaries which develop into seeds after fertilization and are embedded in single chambers along the surface. Seeds are hard, oval in shape and dark brown in color.

Lotus 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 grayish black pericarp which is faintly longitudinally striated, pedunculated and one seeded. Seeds fill in the ripe carpe (Nagarajan *et al.*, 1966) [73].

Fruits of lotus 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 (Sherriff George and Taylor George, 1948) [90].

A large amount of glutathione is contained in the plumule (13/plumule) and cotyledons (164/cotyledon) of lotus, the amount of total plumule in the maturing seed increases gradually. The reduced form of glutathione is dominant in the early stages, while the amount of oxidized form exceeds that of the reduced form at the end of maturation. The amount of reduced form of glutathione in the unripe fruit decreases markedly upon storage for one year. In general the rate of

germination of the stored seeds seems to be closely related to the content of the reduced glutathione (Toyoda, 1966) [94].

A new water soluble quaternary base was isolated from lotus embryo besides the earlier reported isoliendinine, it was named as lotusine and found to be present in the form of a chloride (m.p 213-215°C), a picrate (m.p 212-214°C) and iodide (m.p 202-204°C) which is identical with D-N methyl isocouclaurine methiodide (Furukawa, 1965 [96]; Guo and Chen, 1984 [34]; Chao, 1962 [13]; Furukawa, 1966 [30] and Furukawa, 1967) [31].

Another species of *N. nucifera* is *N. speciosum*. Seeds of *N. speciosum* contained 2.11% oil examined by gas chromatography and UV absorption revealed the presence of myristic acid (0.04%), palmitic acid (17.32%), oleic acid (21.91%), linoleic acid (564.17%) and linolenic acid (6.19%) (Gangrade & Ushal, 1966 [32] and Dhar, and Munjal, 1972) [23].

The alkaloids of lotus embryo were found to possess hypotensive effect (Chao, 1972) [14]. The seeds are used to check vomiting, given to children as diuretic and refrigerant form a cooling medicine for skin diseases & leprosy; considered as antidote to poisons (Chopra *et al.*, 1956) [19]. The essential oil contained in the seeds of *N. speciosum* was found to possess good aphrodisiac effect and possess pronounced nutritive value (Puri, 1971) [84].

Rhizomes

The rhizomes are 60-140 cm long 0.5 to 2.5 cm in diameter. Sheikh (2014) studied that the rhizome bears nodes and each of it produces a leaf. Pal *et al.*, 2015 reported that the color of the rhizome varies from yellowish white to yellowish brown in colour, smooth longitudinally striated with brown patches, nodes and internodes are present. It exudates mucilaginous juice and show a few large cavities surrounded by several larger ones, fracture is tough and fibrous.

Abundant starch grains are present throughout the tissue, alkaloids, sterols and reducing sugars have been detected on preliminary phyto-chemical study form various extract of rhizomes (Mitra *et al.*, 1973) [69]. Fresh rhizomes contain water - 83.80%, fat - 0.11%, reducing sugar - 1.56%, sucrose - 0.41%, crude protein - 2.70%, starch- 9.25%, fibre-0.80%, ash - 1.10% and calcium- 0.06%. The vitamins reported to be present are Thiamine - 0.22 mg/100g, Riboflavin - 0.06 mg/100g, Niacin - 2.1 mg/100g, Ascorbic acid - 1.5 mg/100g. The rhizomes also contain asparagines (2%). The oxalate contents of lotus rhizomes were found to be 84.3mg% (Kaul and Verma, 1967) [47].

Mukherjee *et al.*, (1996) [66] studied that lotus rhizome and its extracts have shown diuretic, psychopharmacological, anti-diabetic, anti-obesity, hypoglycemic, antipyretic and antioxidant activities. Hu *et al.*, 2002 [38], reported that the antioxidant property of rhizome knot extracts has been reported to be higher than those from the whole rhizome. Hadayat *et al.*, (2018) [35] observed that the total phenolic content was found to be 25.49±1.15 mg GAE/g and 17.6±3.80 mg GAE/g dry extract whereas the total flavonoid contents were recorded to be 10.84±0.16 mg RUE/g and 6.86±0.76 mg RUE/g in methanol and ethanolic extract respectively.

Fresh rhizomes are eaten after roasting, white dried slice are used in curry or fried as chips. They are also pickled (Anon., 1966) [4]. Methanolic extract of the rhizome has been found to possess significant hypoglycemic activity. Powdered rhizomes are prescribed for piles as demulcent, beneficial in

dysentery and chronic dyspepsia. External application in the form of paste is useful in scabies and ring worms. Rhizomes yield a kind of nutritious arrowroot given to children for dysentery and diarrhoea (Chatterjee and Pakrashi, 1991 [15]; Kirtikar and Basu, 1975) [49]. Various elements present in lotus pre dried rhizomes at 150° are Ca-1.15%, Cu-0.0015%, Fe-0.053%, Mg-0.398%, Zn-0.0032%, Ba-0.000 64%, K-0.756%, Na-0.1045%.

Lotus as ornamental, nutritive and pharmaceutical supplement

Ornamental value

Lotus plant is mainly known for its ornamental value owing to its beautiful flower and it has an aesthetic value in landscaping mainly for its charming flower petals. Mostly lotus plants are grown in temples for offering its flowers to God. During festival time, it has great demand in the domestic market. In West Bengal, Durga Pooja is an important festival and during this festival time, the lotus flowers have a huge demand in the market. For each pooja 108 numbers of lotus flowers are offered to God and the flower is considered a symbol of fortune in Buddhism. Flower is used as the source of lotus perfume. Dried flowers are used in preparation of fragrant herbal tea. Young leaves, petioles and flowers are eaten as vegetables.

Nutritional value

Lotus plant parts are edible and are used as food source. Miura (1988) [63], states that rhizomes of lotus are used as a fresh cooked vegetable and contain 15-16% carbohydrate. The value-added products of lotus rhizomes are salted, dried flakes, pickles, frozen forms and starch production. Lotus rhizome powder are used as flavouring agents in food production, bakery products etc. Similar to rhizomes, seeds are also edible and they can be eaten raw, cooked, roasted, fried, pickled etc. Lotus seeds are added to soups as a nutrition diet. Flowers are also edible and can be made as tea for decorating food items.

Tender rhizomes, stems and leaves of lotus are edible (Anon., 1992) [6] and can be cooked along with other vegetables, soaked in syrup or pickled in vinegar (Phillips and Rix 1995). Rhizomes consist of 1.7% protein, 0.1% fat, 9.7% carbohydrate and 1.1% ash (Reid 1977) [85] and exhibit mild flavour and extensively used in Chinese recipe, while stem on cooking as food taste like beet (Sturtevant and Hedrick 1972) [94]. Ogle *et al.*, (2001) [78] reported the use of lotus stem (consists of 6, 2.4, 0.2 mg/100 g calcium, iron and zinc respectively) as vegetable and is used in salads in Vietnam.

Petals of lotus are floated in soups or used as a garnish, while the stamens are used in flavoring the tea (Facciola 1990) [26]. Ibrahim and El-Eraqy (1996) [40] reported that Egyptian lotus seeds consist of 14.8% crude protein. The green embryos in the seeds are bitter and usually removed prior to selling in the markets as food product. The seeds can be popped like popcorn, ground into powder and eaten dry or used in bread making. The roasted seeds are good coffee substitute and possess saponins, phenolics and carbohydrates in appreciable quantities (Ling *et al.*, 2005) [100].

Lotus seeds consist of 10.5% moisture, 10.6-15.9% protein, 1.93-2.8% crude fat, 70-72.17% carbohydrate, 2.7% crude fibre, 3.9-4.5% ash and energy 348.45 cal/100 g (Reid 1977) [85] and (Indrayan *et al.*, 2005) [41]. Minerals of lotus seeds consists of chromium (0.0042%), sodium (1%), potassium

(28.5%), calcium (22.1%), magnesium (9.2%), copper (0.0463%), zinc (0.084%), manganese (0.356%) and iron (0.199%).

Zhao *et al.*, (2014)^[104] studied that the water content in raw lotus rhizomes ranged from 77.12%–81.60% w/w and collected from different parts of world *viz.*, Korea (Siheung, Daegu, Haman, and Muan) and Japan (Nigata). Hadayat *et al.*, (2018)^[35] reported that the moisture content (55.3 ± 0.80) and carbohydrates ($23 \pm 0.26\%$) were found to be higher than the concentration of fat ($3.1 \pm 1.67\%$) and fiber ($2.5 \pm 0.86\%$) contents.

Phytochemicals

Many medicinal plants are the richest bio-resources of folk medicines and traditional systems of medicine and it was suggested as food supplements, and play an important role in nutraceuticals, pharmaceuticals and chemical entities for preparing synthetic drugs (Ncube *et al.*, 2008)^[76]. Plant parts are used as phytomedicines and are mainly derived from barks, leaves, flowers, roots, fruits, seeds (Cragg *et al.*, 2001)^[21]. Phytochemicals are the natural bioactive compounds found in plants, which are entirely responsible for their medicinal activity (Saraswathi and Gricilda Shoba 2015)^[86]. They are natural compounds found in plants *viz.*, medicinal plants, vegetables, fruits and flowers that are rich in nutrients and fibres to act against diseases or more peculiarly to protect against diseases.

The phytochemicals are grouped into two main categories reported by Krishnaiah *et al.*, 2009^[51] *viz.*, primary constituents which includes amino acids, common sugars, proteins and chlorophyll etc., and secondary constituents consisting of alkaloids, essential oils, flavonoids, tannins, terpenoids, saponins, phenolic compounds etc. (Krishnaiah *et al.* 2007)^[52].

Lotus is also a rich source of phytochemicals. They are the natural bioactive compounds found in plants, which are solely responsible for their medicinal activity. It is highly essential for the synthesis of complex chemical substances. It is a well-known plant in ancient medical sciences (Majob *et al.*, 2003, Parekh *et al.*, 2007^[81], Jigna and Sumitra 2008^[42], Kalita *et al.*, 2007)^[44]. Lotus rhizome possesses various phytochemicals such as phenolic compounds, flavonoids, saponins, tannins, cardiac glycosides, phlobatanins and alkaloids and the methanolic extract of lotus rhizomes showed high contents of phenols and flavonoids. Lotus rhizome is a good source of carbohydrates and proteins (Hadayat *et al.*, (2018)^[35]).

Majority of phytochemicals have been known to have valuable therapeutic activities such as insecticides (Kambu *et al.*, 1982)^[45] antibacterial, antifungal (Lemos *et al.*, 1990)^[57], anti-constipative (Ferdous *et al.*, 1992)^[27], spasmolytic, anti-plasmodial and antioxidant (Vardar-Ünlü *et al.*, 2003)^[97] activities etc.

The secondary metabolites *viz.*, alkaloids, steroids, tannins, cardiac glycosides, flavanoids, etc. plays a major role against various activities. The alkaloids have the property of antimalarial (Dua *et al.*, 2013)^[24], antimicrobial (Benbott *et al.*, 2012)^[11], anti-inflammatory (Souto *et al.*, 2011)^[92], antispasmodic, cytotoxicity and pharmacological effects (Thite *et al.*, 2013)^[95]. The flavanoids exhibit the property of anti-inflammatory activity (Lee *et al.*, 2003)^[56]. The tannins exposed the property of antitumor and antiviral activities (Kumari and Jain 2012)^[53] and also antibacterial activities

(Akiyama *et al.*, 2001)^[2]. The steroids possess the activity of cardiostimulant effect, antibacterial and insecticidal properties (Bagrov *et al.*, 2009)^[10]. Cardiac glycosides have the property against congestive heart failure and cardiac arrhythmia (Kren and Martínková 2001)^[50]. Other secondary metabolites also have some biological activities such as antimicrobial (Al-Hussaini and Mahasneh 2009)^[3], antioxidant (Abdoul-Latif *et al.*, 2010)^[1], anti-acne activities (Harisaranraj *et al.*, 2010)^[36].

Lotus flowers

The ether and aqueous extract of the petals, stamens and torus of *Nelumbo speciosum* gave typical color reactions for flavanoids, the concentrate from the ether extract on ascending and descending paper chromatography showed the presence of quercetin and luteo (confirmed by column chromatography) in the case of petals and stamens, only quercetin was present in torus, the aqueous extract on further concentration showed the presence of iso-quercetin and glucoluteolin in the case of petals and stamens while the torus contain only iso quercetin. The sugar was identified in each case as glucose only by paper chromatography and the osazone (Nagarajan *et al.*, 1966)^[73]. The flowers also contain a glycoside kaempferol (kaempferol- 3- galactopyranoside). The flowers has cooling effect, used as astringent in diarrhea, also in cholera, in fever and diseases of liver, recommended as a cardiac tonic (Chopra *et al.*, 1956)^[19].

Bernays *et al.*, (1989)^[9], examined that polyphenols have the activity of inhibition of digestive enzymes and/or precipitate nutritional proteins contents. Joyce (1987)^[43], reported that phenolic compounds and flavonoids were integrated with antioxidant activity and plays a vital role in stabilizing lipid-per oxidation. Zheng and Wang (2001)^[105] and Dorman *et al.*, (2003)^[25], stated that the stabilization of lipid peroxidation was done by adsorbing and neutralizing free radicals, quenching singlet and triplet oxygen or decomposing peroxides.

Saraswathi and Gricilda Shoba (2015)^[86] observed that quantification of carbohydrate, in the hydro ethanolic lotus petal extract showed that it serves as a rich source of energy (15.66 w/w). Very moderate amount of protein (4.12 w/w) was quantified and has very low lipid content (0.38w/w). In that study, petal extract showed a high concentration of tannin (23.14 ± 1.76 mg/g) comparing to the other phytochemicals present in the lotus petal extract. Tannins were said to be water-soluble polyphenolic compounds and have astringent property. Tannins act as an antimicrobial agent against the growth of fungi and yeasts (Chung *et al.*, 1998), bacteria and viruses (Akiyama *et al.*, 2001)^[2].

Saraswathi and Gricilda Shoba (2015)^[86] reported that hydro ethanolic petal extract of lotus had a phenol content of 18.56 ± 2.33 mg/g respectively. Haslam *et al.*, (1981)^[37] and Lu *et al.*, (2004)^[59], stated that phenolic compounds were pervasive distributed in the plant kingdom that exhibit a wide range of pharmacological and medicinal properties, *viz.*, UV protective agents, defensive compounds against herbivores and pathogens, contributors to plant colors, act as an important ingredient to add taste to food, drinks and pharmaceuticals.

Saraswathi and Gricilda Shoba 2015^[86] observed that flavonoids have been reported to be the third highest concentration (18.56 ± 2.33 mg/g) after phenol content. In addition to that, flavonoids are highly helpful for inhibiting

lipid-per oxidation, platelet aggregation, capillary permeability and fragility, cyclo-oxygenase and lipoxygenase enzyme activities. They exert wide range of biological activities includes, antibacterial anti-inflammatory, antiviral, anti-allergic activities (Cushnie and Lamb 2005) [122], treatment of neurodegenerative diseases, cytotoxic, anti-tumour, vasodilator action (Williams *et al.*, 2004) [199] and (Chebil *et al.*, 2006) [116]. They influence these effects as antioxidants, free radical scavengers, chelators of divalent cation (Chebil *et al.*, 2006 [116], Middleton *et al.*, 2000) [162]. Petals of lotus have the potential to act as a source of useful drugs because of the existence of various phytochemical components such as carbohydrate, protein, phenols, tannin, flavonoids and alkaloids (Saraswathi and Gricilda Shoba 2015) [186].

Lotus seeds

In traditional medicine, lotus seeds are used as spleen tonic (Follett 2003) [128] and seed powder is used against cough (Khare 2004) [148]. Plumule from the ripe seed is used for the treatment of many diseases, including nervous disorders, insomnia, high fevers with restlessness and hypertension (Nguyen 1999) [177]. The seeds or their extracts have been reported to possess anti-proliferative (Yu and Hu 1997) [103], anti-fibrosis (Xiao *et al.*, 2005) [100], antidepressant, antiinflammation (Bi *et al.*, 2006), astringent (Nguyen 1999) [177], hepatoprotective and free radical scavenging (Ono *et al.*, 2006) [179], anti-obesity and hypolipidemic effects (You *et al.*, 2013) [102], anti-inflammatory, immunomodulatory (Mukherjee *et al.*, 1997) [67] and antiviral activities (Kashiwada *et al.*, 2005) [146].

Leaves

Chopra and Nayar (1956) [19] reported that the leaves of lotus plants were used to treat many bleeding disorders. Preethika *et al.*, (2017) [183] studied that phytochemical screening of lotus leaves showed the presence of phenols, tannins, alkaloids, steroids, terpenoids, coumarin, quinine etc., from different solvent extracts. Choe *et al.*, (2010) [118] observed that the phenol and flavanoid content of lotus leaves (15.2 ± 0.10 and 106.9 ± 0.13) were high in methanol extract than ethanol extract (9.8 ± 0.4 and 69.5 ± 0.10).

Antioxidants

Arjun *et al.*, (2012) [7], reported that DPPH (1, 1-Diphenyl-2-picrylhydrazyl) freeradical scavenging activity was high in methanolic leaf extract of lotus compared to other extracts. The methanolic leaf extract of lotus exhibited strong hydrogen donating abilities to act as an effective antioxidant. The scavenging effect was increased with increasing concentration of the extract. Choe *et al.*, (2010) [118] studied that the 2, 2-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity of methanol extract of leaf was higher than that of the other extracts. And also he reported that lotus leaves extracted by methanol and ethanol that have antioxidant activities may be alternatives to synthetic antioxidants in the food industry. (Baehaki *et al.*, 2015) [8] stated that antioxidant activities might protect biological systems against damage related to oxidative stress in human disease conditions.

Pharmaceutical value

Traditional knowledge reveals many medicinal uses of lotus plant. The whole plant serves as astringent, emollient, diuretic

and sudorific and possesses antifungal, antipyretic and cardiotoxic. Different parts of the lotus plant are useful in treatment of diarrhea, tissue inflammation and haemostasis (Yu and Hu, 1997) [103]. The rhizome extract has anti-diabetic (Mukherjee *et al.*, 1997a) [67] and anti-inflammatory properties due to presence of asteroloidal triterpenoid (Mukherjee *et al.*, 1997b) [67]. Young leaves with sugar are useful to treat rectal prolapse and the leaves boiled with *Mimosa pudica* in goat's milk can be used to treat diarrhea. Leaf powder has healing effect to arrest the blood flow from the wound. Leaf paste can be applied to the body during fever and inflammatory skin conditions. Leaves are used as effective drug for hematemesis, epistaxis, hemoptysis, hematuria and metrorrhagia. Hyperlipidaemia in rodents can be treated with lotus leaves. Leaves also possess diuretic and astringent properties and help to treat fever, sweating and strangury and as styptic (Chinese Material Medical, 1977).

In folk medicines, seeds are used in the treatment of tissue inflammation, cancer, skin diseases, & leprosy. It is generally prescribed to children as diuretic and refrigerant (Chopra *et al.*, 1956) [19]. The fruits and seeds of lotus are astringent and used to treat hyperdipsia, dermatopathy, halitosis, menorrhagia, leprocy and fever (Nadkarni, 1982) [170]. Seed powder mixed with honey is useful in treating cough, while roots with ghee (melted fresh butter), milk promote strength, virility and intellect. Lotus seeds have been reported to possess rich antimicrobial properties (Mukherjee *et al.*, 1955; Mukherjee, 2002) [65, 64]. Embryo of lotus seeds are used in traditional Chinese drug called 'Lian Zi Xin', which primarily helps to overcome nervous disorders, insomnia, high fever and cardiovascular diseases (Chen Yi *et al.*, 2007) [17].

Traditionally all parts of lotus have various medicinal uses. Rhizomes are prescribed as demulcents for haemorrhoids and are beneficial in dysentery, chronic dyspepsia, and have nutritive, diuretic and cholagogue activities. The stem is used in indigenous Ayurvedic medicine as a diuretic and anthelmintic and to treat strangury, vomiting, leprosy, skin disease and nervous exhaustion. The leaves are used for the treatment of haematemesis, epistaxis, haemoptysis, haematuria, metrorrhagia and hyperlipidaemia (Huan Du *et al.*, 1984) [39]. The flowers are useful in the treatment of diarrhoea, cholera, fever and gastric ulcers (Sridhar and Bhat, 2007) [93].

Wang and Zhang (2004) [98] studied that in Asian culture, whole parts (seeds, rhizomes, nodes, leaf, roots, young shoots, stamens, petals, stalks, and pericarps) of lotus are eaten as food or used for medicinal purposes. In traditional system of medicine, the different parts of plant are reported to possess beneficial effects for the treatment of common infections, skin, respiratory and reproductive diseases.

Some new bioactive drugs and compounds were isolated from leaves of lotus such as flavonol miquelianin (Quercetin 3-O-glucuronide), as well as the alkaloids (+)-1(R)-coclaurine and (-)-1(S)-norcoclaurine. The plant also contains nuciferine and aporphine. It also contains three bisbenzylisoquinoline alkaloids, nelumboferine and nelumborines A and B, which were isolated along with four known compounds, neferine, liensinine, isoliensinine and anisic acid (Shen *et al.*, 2002) [188]. A wide variety of chemical constituents are isolated from various parts of lotus.

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 nuciferine, roemerine, anonaine, pronuciferine and N-nornuciferine. Six non-phenolic bases were identified: roemerine, nuciferine, anonaine, pronuciferine, N-nornuciferine and liriodenine and two phenolic bases, arnepavine and N-methyl-coclaurine were also found in lotus leaf extract (Kunitomo *et al.*, 1973) [54]. Dehydroemerine, dehydronuciferine, dehydroanonaine, N-methylisococclaurine, anonaine, pronuciferine, N-nornuciferine, O-nornuciferine, nuciferine, roemerine, roemerine, arnepavine, liensinine, isoliensinine, negferine, asimilobine and lirinidine were isolated from leaves and petioles (Kashiwada *et al.*, 2005; Xubiao Luo *et al.*, 2005;

Tomita *et al.*, 1965 and Shoji, 1987) [46, 101, 96, 91]. The leaves also contain a glycoside, nelumboside, and flavonoids such as quercetin and leuco-anthocyanidin which were identified as leucocyanidin and leucodelphinidin (Nakaoki, 1961; Nagarajan, 1966) [73]. The presence of some other flavonoids in the leaves such as quercetin 3-O-a-arabinopyranosyl (1, 2)-galactopyranoside, quercetin-3-O-Dglucuronide, rutin, (+)-catechin, hyperoside, isoquercitrin and astragalin has also been reported by Kashiwada *et al.*, 2005 [46].

As home remedy, lotus leaves are useful to treat summer heat syndrome in Japan and China and used to treat obesity in China (Ono *et al.*, 2006) [79].

Table 1: Traditional uses of different parts of lotus

Part	Traditional uses
Whole plant	Used for the treatment of liver disorders in Ayurveda. Leaves, roots for diabetes, blood disorders, antifertility, heart troubles, dysentery, eruptive fevers, indigestion and as a cardiotoxic, emollient, diuretic, narcotic, stimulant, and aphrodisiac
Rootstock	Powder is used to treat dyspepsia, diarrhea, and piles
Flower	3 – 6 g of the drug is used in burning thirst, bile-blood, vomiting, fainting, heart disease, painful discharge of urine, a class of urinary affections, diarrhea with fever
Root	The roots are used as an emollient, diuretic, and to treat diabetes, infection of the urinary passages and infertility
Leaf and flower	The tender leaves and flower peduncles are used as curries
Rhizome and stem	An infusion is considered to be an emollient, diuretic, and used for treatment of blennorrhagia and diseases of the urinary tract
Flower and rhizome	Flowers and rhizomes are astringent, demulcent, mild sedative, spasmolytic, antiseptic, used in infusion internally for chronic diarrhea, as a douche for leucorrhoea and vaginitis as a gargle for sore throat; also given internally for prostate problems
Seed	The seeds are said to be stomachic and restorative. Seeds are prescribed as a diet for diabetes mellitus, in the Ayurvedic system of medicine

Conclusion

Lotus is a well-known aquatic flower to everybody in our country where it is considered as a national flower. Generally, people collect lotus flowers from spontaneous growth of the plant, but to cultivate the plant commercially is out of conception. Growing demand of lotus especially for flower has motivated farmers and lotus lovers to think about their values. During festival there is a huge demand of flowers according to rituals. India is a country where lotus can be found abundantly in wetlands, ponds, lakes, canals etc. Each part signifies that they can be used effectively as a therapeutic agent for nutritional therapy and phytotherapy for the alleviation of various diseases. Lotus rhizomes and seeds have high nutritive value. Knowing the importance and uses of this crop, conservation and cultivation of this underutilized aquatic crop assumes significance. Ancient systems like Ayurveda used the plant in different ways. Hence, this crop is a boon for Indian people as food, ornament and medicinal value.

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