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A REVIEW ON THERAPEUTIC POTENTIAL OF *NELUMBO NUCIFERA (GAERTN):* THE SACRED LOTUS

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ABSTRACT: objectives: *Nelumbo nucifera Gaertn (Nelumbonaceae)* known by numerous common names including Indian lotus, sacred lotus, bean of India, or simply lotus is one of the most important medicinal plants. In this review there is discussion about therapeutic potential of the different parts of the plant (leaves, seeds, flower, and rhizome) which can be used in traditional system of medicine. This review also describes various compounds isolated from different parts of the plant and therapeutic benefits derived from those phytocontituents. The aim of this review is to summarize the pharmacological, phytochemical and therapeutical knowledge of *Nelumbo nucifera Gaertn*. **Key findings:** The pharmacological studies have shown that *N. nucifera* possesses various pharmacological activities like anti-ischemic, antioxidant, anticancer, antiviral, antiobesity, lipolytic, hypocholestemic, antipyretic, hepatoprotective, hypoglycemic, antidiarrhoeal, antifungal, antibacterial, anti-inflammatory and diuretic activities. Several different types of compounds have been derived from this plant belonging to different chemical groups, including alkaloids, flavonoids, glycosides triterpenoid, etc., with own therapeutic impact. So the pharmacological effects and various active ingredients of different parts of *N. nucifera* are well understood. **Summary:** This review will facilitate to gain all about the past scientific research and will provide the necessary information about the enormous pharmacological activities of *Nelumbo nucifera Gaertn* which will insist the researchers for future research to protect human beings from various types of diseases and may serves as a natural gold for the promotion of mankind.

INTRODUCTION: Herbal Medicine is the oldest form of medicine known to mankind. It is the most widely practiced form of medicine in the world according to World Health Organization figures. Herbal medicine is still the mainstay of about 75 - 80% of the world population, particularly in the developing countries, for primary health care. According to the World Health Organization (WHO), the use of herbal remedies throughout the world exceeds that of the conventional drugs by two to three times. Nature provides a medicine cabinet full of extraordinary herbs and flowers, which form the basis for many modern medicines [1]. Herbal medicines are represented as the most important field of alternative medicines all over the world.

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Hence, it is very essential to study the medicinal plants in order to promote their proper use and also to determine their potential as the primary source for the preparation of new drugs. The chemical constitutes of the plant may be therapeutically active or in active. Indian system of medicine (Ayurveda, Unani, Siddha, Yoga and Naturopathy) is primarily based on the medicinal plants which have been developed over a long period of time. Herbal medicines are getting more importance in the treatment of different diseases because the modern synthetic medicines have side effects [2].

Nelumbo nucifera Gaertn: The Sacred Lotus:

Nelumbo nucifera Gaertn (Nelumbonaceae) known by numerous common names including Indian lotus, sacred lotus, bean of India, or simply lotus, is one of two species of aquatic plant in the family Nelumbonaceae. 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. Herbal medicines are represented as the most potential

field of alternative medicines all over the world for a number of diseases in which allopathic medicines have no or little solution. For this reason, a large proportion of the Indian population for their physical and psychological health depends largely on traditional system of medicines. Several attempts have seen made to control this problem, in which herbal medicines have shown some encouraging results and touted as an important adjuvant therapy [3].

History of plant:

In ancient times, lotus was common along the banks of the river Nile, together with the closely related species "sacred blue lotus". The Egyptians worshipped the lotus flowers, fruits and sepals, which were widely depicted as architectural motifs. From Egypt, it was carried to Assyria and widely planted throughout Persia, India and China. Nowadays it can be seen almost everywhere in modern botanical garden collections. It is a common plant in Australia, China, India, Iran and Japan. It was introduced from China into Japan and has been cultivated for more than 1000 years. In China, it is an industrial crop grown on over 40 000 hectares. In India, it is widespread and has even been found in Himalayan lakes [24]. Traditionally all parts of *N. nucifera* 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 [25, 26].

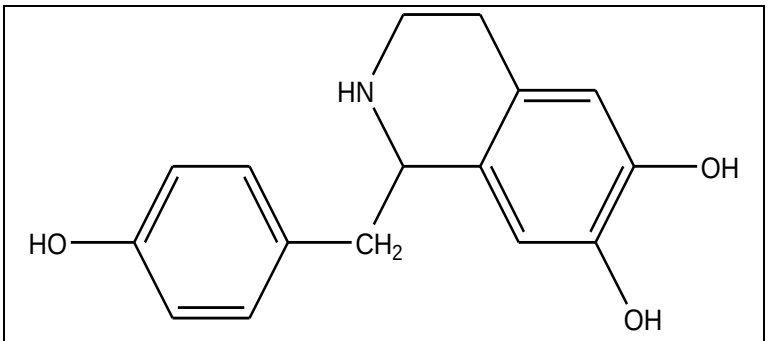
The stem is used in indigenous Ayurvedic medicine as a diuretic and anthelmintic and to treat strangury, vomiting, leprosy, skin disease and nervous exhaustion. The leaves are used for the treatment of haematemesis, epistaxis, haemoptysis, haematuria, metrorrhagia and hyperlipidaemia [27]. The flowers are useful in the treatment of diarrhoea, cholera, fever and gastric ulcers [24].

FIG.1: *NELUMBO NUCIFERA* FLOWER& TORUS

FIG.2: *NELUMBO NUCIFERA* (A) DRY SEEDS (B) CUT OPEN SEEDS

The review describes some new bioactive drugs and isolated compounds from plant such as flavonol miquelianin (Quercetin 3-O-glucuronide), as well as the alkaloids (+)-1(R)-coclaurine and (-)-1(S)-norcoclaurine, which can be found in the leaves of *N. nucifera*. 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 [3]. A wide variety of chemical constituents are isolated from various parts of *N.nucifera.* The structures of major chemical constituents of plant are shown in figure. **Fig. 3-9.**

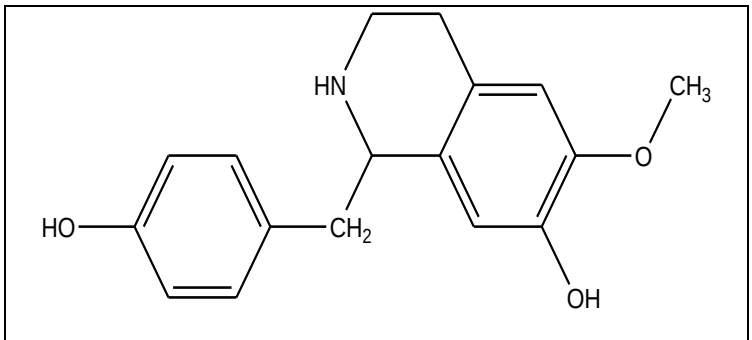
Combined gas/liquid chromatography–mass spectroscopy has shown that the leaves are rich in a number of alkaloids. In the analysis of non-phenolic fractions of the leaf extract, the major components had retention data and mass spectra identical to those of nuciferine, roemerine, anonaine , pronuciferine and N-nornuciferine. Six non-phenolic bases were identified: roemerine, nuciferine, anonaine, pronuciferine, N-nornuciferine and liriodenine and two phenolic bases, armepavine and N-methyl-coclaurine were also found in *N. nucifera* leaf extract [28]. Dehydroemerine, dehydronuciferine, dehydroanonaine, N-methylisococlaurine, anonaine, pronuciferine, N-nornuciferine, O-nornuciferine, nuciferine, remerine, roemerine, armepavine, liensinine, isoliensinine, negferine, asimilobine and lirinidine were isolated from leaves and petioles [29, 30, 31, 32]. The leaves also contain a glycoside, nelumboside, and flavonoids such as quercetin and leuco-anthocyanidin which were identified as leucocyanidin and leucodelphinidin [33, 34]. The presence of some other flavonoids in the leaves such as quercetin 3-O-a-arabinopyranosyl-(1,2)-galactopyranoside, quercetin-3-O-D-glucuronide, rutin, (+)-catechin, hyperoside, isoquercitrin and astragalin has also been reported [29].



NORCOCLAURINE

1-(4-hydroxybenzyl)-1,2,3,4-tetrahydroisoquinoline-6,7-diol

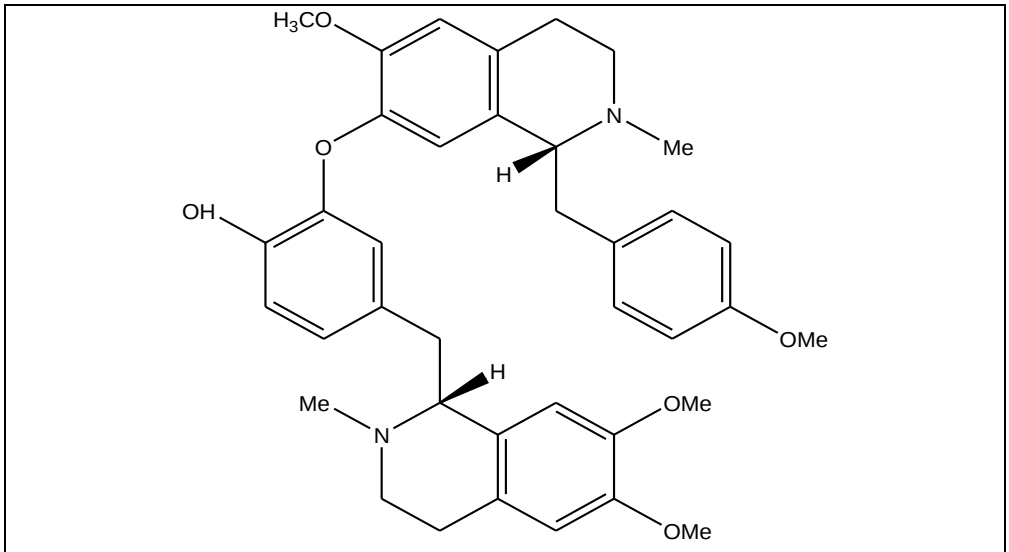
FIG. 3: NORCOCLAURINE



(RS)-COCLAURINE

1-(4-hydroxybenzyl)-6-methoxy-1,2,3,4-tetrahydroisoquinolin-7-ol

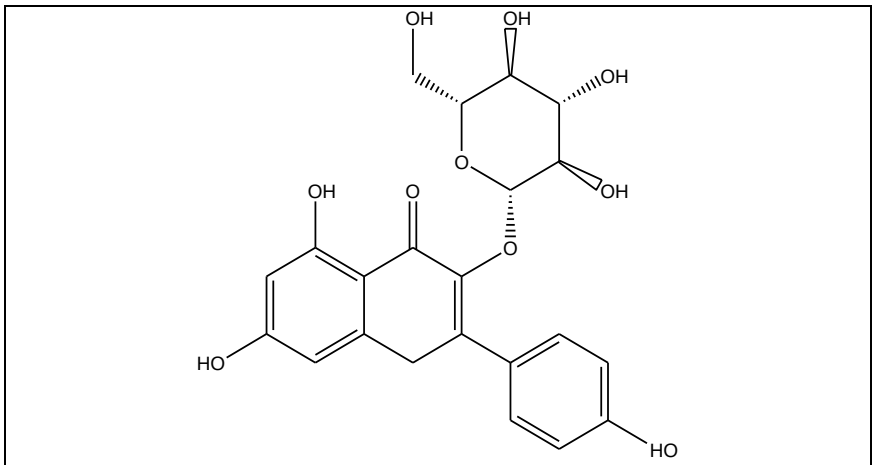
FIG. 4: (RS)-COCLAURINE



NEFERINE

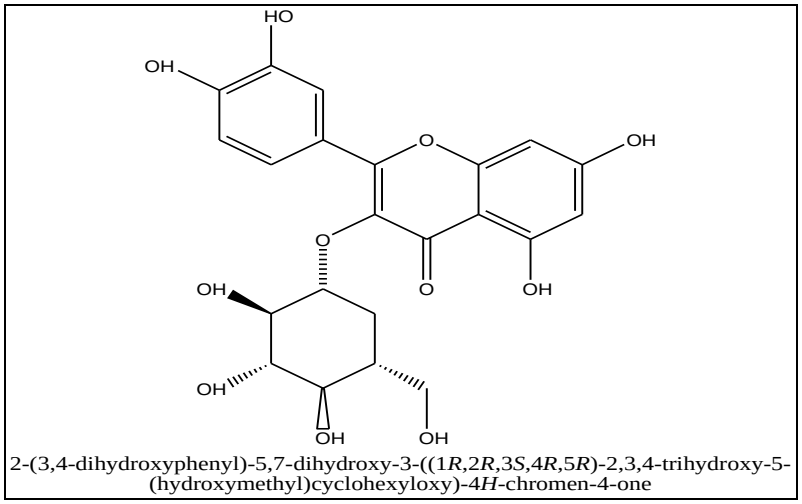
2-((*R*)-1-(4-methoxybenzyl)-6-methoxy-2-methyl-1,2,3,4-tetrahydroisoquinolin-7-yloxy)-4-(((*R*)-6,7-dimethoxy-2-methyl-1,2,3,4-tetrahydroisoquinolin-1-yl)methyl)phenol

FIG.5: NEFERINE



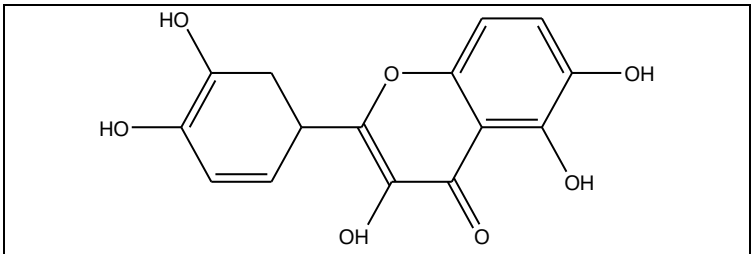
6,8-dihydroxy-3-(4-hydroxyphenyl)-2-((2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)-tetrahydro-2*H*-pyran-2-yloxy)naphthalen-1(4*H*)-one

FIG. 6: ASTRAGALIN (37)



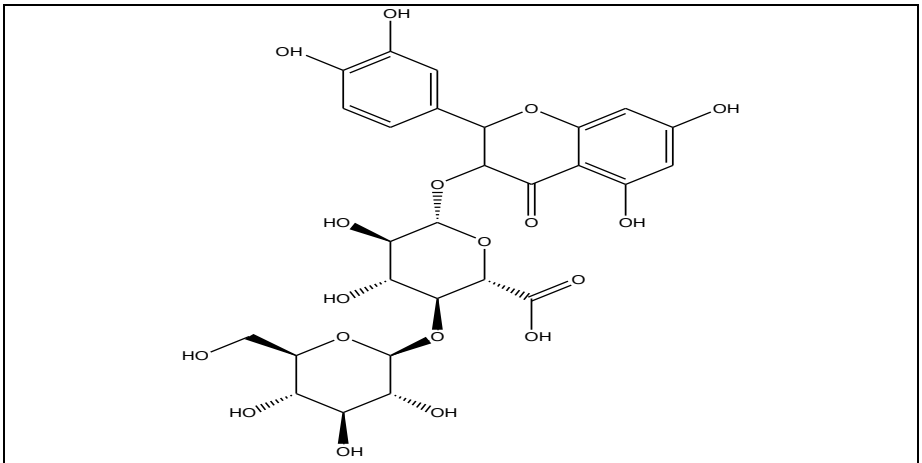
2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-((1*R*,2*R*,3*S*,4*R*,5*R*)-2,3,4-trihydroxy-5-(hydroxymethyl)cyclohexyloxy)-4*H*-chromen-4-one

FIG.7: ISOQUERCITRIN (36)



2-(4,5-dihydroxycyclohexa-2,4-dienyl)-3,5,6-trihydroxy-4*H*-chromen-4-one

FIG.8: QUERCETIN (29)



(2*S*,3*S*,4*R*,5*R*,6*R*)-6-(2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-4-oxochroman-3-yloxy)-4,5-dihydroxy-3-((2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-(hydroxymethyl)-tetrahydro-2*H*-pyran-2-yloxy)-tetrahydro-2*H*-pyran-2-carboxylic acid

FIG. 9: NELUMBOSIDE (28)

The present study was undertaken to scientifically investigate the therapeutic potential of medicinal plant *Nelumbo nucifera Gaertn* including the clinical & preclinical results with safety & efficacy. *Nelumbo nucifera Gaertn* (Nymphaeaceae) is a well-known medicinal plant in ancient medical sciences. Almost all parts of *Nelumbo nucifera* are edible, and in many Asian countries it was found in the recipe of food. Extracts of *N. nucifera* flowers, seeds, rhizomes and leaves have been reported to have varied therapeutic potential including allelopathic effect, antiobesity, anti-HIV, antioxidant, diuretic, astringent, anti-inflammatory, hepatoprotective antipyretic, and antibacterial immunomodulatory activities [3].

The pharmacological activities of *Nelumbo nucifera* are given in **Table 1 & Fig.10**. [3]

TABLE 1: PHARMACOLOGICAL ACTIVITIES OF DIFFERENT PARTS OF LOTUS

Activity	Part of plant used	Reference(s)
Aldose reductase inhibitory	Flower	55
Anti-arrhythmic	Seed	56-58, 59, 60
Anti- bacterial	Flower	61
Anticancer	Leaves	62
Anti-diarrhoeal	Rhizome	63
Anti-fertility	Seed	64
Anti-fibrosis	Seed	65
Anti-ischaemic	Seed	66
Anti-inflammatory	Seed, Rhizome	6, 46
Anti-obesity	Leaves	[80]
Antioxidant	Leaves, Flower, Rhizome	68, 69,70, 71, 72,73
Antiplatellet	Flower	74
Anti-proliferative	Seed	75,76
Antipyretic activity	Flower, Rhizome	74, 77
Antiviral	Seed, Leaves	78, 79
Aphrodisiac	Flower	80
Cardiovascular activity	Leaves	81
Diuretic activity	Rhizome	82
Hepatoprotective	Seed, Leaves	83
Hypocholesterolaemic	Leaves	84
Hypoglycaemic	Flowers, Rhizome	85, 86
Immunomodulatory	Seed, Rhizome	87
Lipolytic	Leaves	88
Psychopharmacological	Rhizome	89

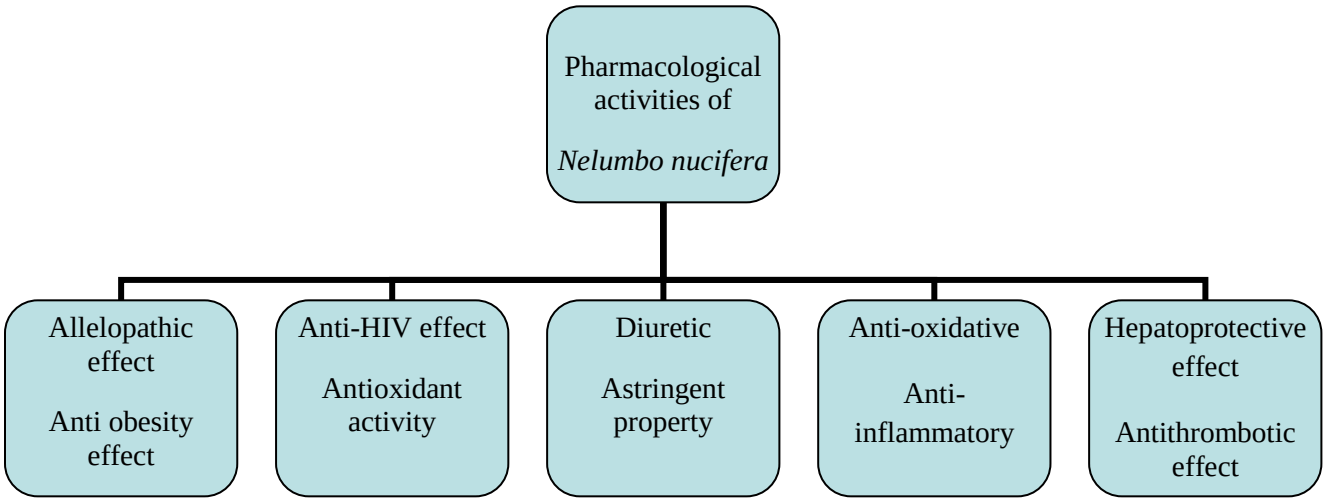


FIG.10: PHARMACOLOGICAL ACTIVITIES OF *N. NUCIFERA*

Allelopathic effect:

The present study was undertaken to evaluate allelopathic effect of *Nelumbo nucifera* stem and leaf tissue extract. The leaf extract inhibited algae blooms more effectively than the stem extract on the whole. When the leaf extract normality was 25 g x L(-1), the highest inhibition rate of *Microcystis aeruginosa* and *Scenedesmus quadricanda* was 71.33% and 78.14%, respectively, while for the stem extract, the values were 49.78% and 52.14%. Propanamide was found in both the stem and leaf tissue extracts of *Nelumbo nucifera* by GC-MS analysis, with concentrations of 1.1 mg x L(-1) and 0.2 mg x L(-1), respectively. The EC50 values of the two kinds of algae were calculated by the probability method [4].

Lipolytic activity:

The lipolytic activity of petal extracts of *N. nucifera* was tested. The petal extracts of *N. nucifera* clearly exhibit lipolytic activity in a dose-dependent manner in murine 3T3-L1 fibroblasts. It was also found that the dietary fat is not directly absorbed by the intestine unless the fat has been subjected to the action of pancreatic lipase. Therefore, pancreatic lipase is one of the most widely studied mechanisms for determining natural products and potential efficacy as antiobesity agents. In this study, they reported the inhibitory effects of *Nelumbo nucifera* petal extracts on pancreatic lipase. Methanol extract elicited an inhibitory effect on lipase enzyme with an IC_{50} value of 47 μg/mL. *Nelumbo nucifera* is known as sacred lotus and found to have various pharmacologically active substances including alkaloids, flavonoids, triterpenoids, polyphenols, steroids, and glycosides. A phytochemical investigation of *N. nucifera* leaves led to the isolation of eight alkaloids and some of these significantly inhibited pancreatic lipases. The petal extract of *N. nucifera* possesses lipolytic activity[5].

Antiviral activity:

The Antiviral activity of *Nelumbo nucifera* was evaluated & it was found that (+)-1(R)-Coclaurine (1) and (−)-1(S)-norcoclaurine (3), together with quercetin 3-O-β-d-glucuronide (4), which were isolated from the leaves of *Nelumbo nucifera* possess antiviral activity [6].

Antiobesity effect:

The present study was undertaken to evaluate antiobesity effect of the plant. The *Nelumbo nucifera* seed ethanol extract demonstrated an inhibitory effect on adipogenesis. In addition, NSEE had a beneficial effect, reducing adipose tissue weights, ameliorating blood lipid profile, and modulating serum leptin level in rats fed a high-fat diet. Therefore, they suggest that lotus seed has a potential to be developed as an effective agent against obesity-related diseases [7].

In another study *Nelumbo nucifera* leaves extract has been screened for its antiobesity effect. NNE is found to be beneficial for the suppression of obesity. *Nelumbo nucifera* has been used for summer heat syndrome as home remedy in Japan and China, and it has recently been used to treat obesity in China. So they investigate the pharmacological mechanism of the anti-obesity

effect of *Nelumbo nucifera* leaves extract (NNE). They examined the effect of NNE on digestive enzyme activity, lipid metabolism and theromogenesis and evaluated the effects of anti-obesity using high-fat diet-induced obesity in mice that were treated with NNE for 5 weeks.NNE prevented the increase in body weight, parametrial adipose tissue weight and liver triacylglycerol levels in mice with obesity induced by a high-fat diet. UCP3 mRNA expression in skeletal muscle tended to be higher, when mice were administrated by NNE and were exercised. Therefore, NNE impaired digestion, inhibited absorption of lipids and carbohydrates, accelerated lipid metabolism and up-regulated energy expenditure. Consequently, NNE is beneficial for the suppression of obesity [8].

Antioxidant activity:
The antioxidant potential of hydro alcoholic extract of *Nelumbo nucifera* seeds (HANN) was evaluated using in vitro and in vivo models. Total phenolic content in HANN was found to be 7.61 +/- 0.04% (w/w). Characteristic HPTLC fingerprints of HANN were also made using different solvent systems. The HANN exhibited strong free radical scavenging activity. The results support significant antioxidant nature of HANN [9].

Diuretic & Astringent:
Aqueous extract of dried roots of *Nelumbo nucifera* was tested for diuretic and astringent activity. Plant has been used for various medicinal purposes as in Chinese herbal medicine. In particular, the leaves are known for diuretic and astringent properties, and are used to treat obesity. In subsequent experiments, dietary supplementation of NN resulted in a significant suppression of body weight gain in A/J mice fed a high-fat diet [10].

Hypoglycemic effect:
Hypoglycemic effect of the plant was evaluated. Pancreatic α-amylase inhibitors property of the plant offers an effective strategy to lower the levels of post prandial hyperglycemia via control of starch breakdown. Eleven Ayurvedic Indian medicinal plants with known hypoglycemic properties were subjected to sequential solvent extraction and tested for α-amylase inhibition, in order to assess and evaluate their inhibitory potential on pancreatic α-amylase. Phytochemical analysis revealed the presence of alkaloids, proteins, tannins, cardiac glycosides, flavonoids, saponins and steroids as probable inhibitory compounds [11].

Anti-oxidative & Anti-inflammatory activity:
Anti-oxidative and anti-inflammatory activities of *Nelumbo nucifera* were assessed. Scientists studied the effects of allantoin on cognitive function and hippocampal neurogenesis & found that allantoin is contained in *Nelumbo nucifera* & a well-known cosmetic ingredient reported to have anti-oxidative and anti-inflammatory activities. These findings suggest that allantoin has therapeutic potential for the cognitive dysfunctions observed in Alzheimer's disease [12].

Antibacterial activity:
The antibacterial activity of *Nelumbo nucifera* seed extract was carried and found that Silver nanoparticles (AgNPs) which were synthesized using a *Nelumbo nucifera* dry seed extract, is a simple, non-toxic, eco-friendly "green material". X-ray diffraction (XRD) confirmed the crystalline nature of AgNPs. These AgNPs were highly toxic to Gram negative bacteria[13].

Hepatoprotective effect:
The ethanol extract of *Nelumbo nucifera* seeds was evaluated for its hepatoprotective & free radical scavenging effect. Scientists found that ethanol extracts from *Nelumbo nucifera* (ENN) seeds have possible antioxidative and hepatoprotective effects. These hepatoprotective effects of *Nelumbo nucifera* might result from its potent antioxidative properties [14].

In another study it was found that most of the liver-related morbidity and mortality are associated with the development of cirrhosis, which is most likely to occur in individuals who have progressed from hepatic steatosis to steatohepatitis. The processes by which steatohepatitis evolves from hepatic steatosis are not fully understood; nevertheless, developing effective therapies for treating NAFLD is necessary, and discovering nutrients that can reduce the risk of NAFLD would be useful. They demonstrated that the Polyphenolic extract of lotus root (edible rhizome of *Nelumbo nucifera*)

alleviates hepatic steatosis in obese diabetic db/db mice [21].

Antithrombotic effect:

The present study was undertaken to evaluate antithrombotic effect of *Nelumbo nucifera* and they found that Neferine remarkably prevents thrombus formation by inhibiting platelet activation, adhesion and aggregation, as well as promoting disassembly of pre-formed platelet aggregates. The inhibitory effects of neferine on platelet activation might be relevant in cases involving aberrant platelet activation where neferine could be used as an anti-platelet and antithrombotic agent [15].

Anti-inflammatory effect:

Anti-inflammatory effect of the plant was studied & they assessed that the *Nelumbo nucifera* extracts were considered to have the best anti-inflammatory ability of the four *LN* organs, and the chemical material basis (CMB) of this biological activity was successfully validated by multivariate statistical analysis and biological research methods [16].

Anticancer effects:

The medicinal application of *Nelumbo nucifera* in the treatment of various diseases demonstrated its anticancer effects. Neferine, an alkaloid from *N. nucifera* was found to exert cytotoxicity on liver cancer cells HepG2 in a dose-dependent manner. They evaluated its anticancer potential by studying its effect on mitochondrial membrane potential, intracellular calcium levels, cell membrane integrity, apoptotic body formation and DNA fragmentation in cultured HepG2 cells [18].

In another study it was found that hepatocellular carcinoma (HCC) is one of the most aggressive malignant diseases and is highly resistant to conventional chemotherapy. Neferine, a major bisbenzylisoquinoline alkaloid derived from the embryos of *Nelumbo nucifera*, has been reported a few physiological activities. However, the mechanisms of anticancer effects are not well understood and its detailed activities on Hep3B cells have not been determined [19].

Anti-diabetic effect:

This study was performed to evaluate the anti-diabetic effects of the plant. Scientists found that Nuciferine stimulates insulin secretion from beta cells. They found that among several compounds extracted from anti-diabetic plants, nuciferine was found to stimulate insulin secretion by closing potassium-adenosine triphosphate channels, explaining anti-diabetic effects of *Nelumbo nucifera* [20]. The other study demonstrated that *Nelumbo nucifera* leaf flavonoids (NLF) inhibit lipase, α-glucosidase, and α-amylase activities in vitro. Furthermore, the NLF significantly lowered the lipid components, such as the total cholesterol, triglycerides, low-density lipoprotein cholesterol, and malondialdehyde, in various established *in vivo* systems and raised the high-density lipoprotein cholesterol. Moreover, the NLF alleviated high-fat diet-induced lipid accumulation in the liver. These findings may provide new pharmacological basis for the treatment of hyperlipidemia, hyperglycemia, and obesity using NLFs [17].

Immunomodulatory effect:

Immunomodulatory effect was evaluated by analyzing the effects of neferine, a bisbenzylisoquinline alkaloid extracted from the Chinese traditional medicine seed embryo of *Nelumbo nucifera Gaertn*, on amiodarone-induced pulmonary fibrosis in mice. The results indicated that neferine possessed a significant inhibitory effect on amiodarone-induced pulmonary fibrosis, probably due to its properties of anti-inflammation, SP-D inhibition and restoring increased CD4+CD25+ Tregs which may modulate Th1/Th2 imbalance by suppressing Th2 response [22].

Antidiarrhoeal activity:

The antidiarrhoeal potential of *N. nucifera* rhizome extract has been reported. The extract produced significant inhibitory effects against castor-oil-induced diarrhoea and PGE_2-induced enteropooling; the propulsive movements of a charcoal meal were also reduced significantly [23].

Antimicrobial activity:

Different extracts of rhizome showed significant antibacterial effects against micro organisms like *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *B. pumilis* and *Pseudomonus aeruginosa*. The chloroform extract was found to be the most effective when compared with the standard drug chloramphenicol [23].

Antifungal and anti-yeast activity:
Lotus rhizome extract were evaluated against five different strains of fungi and yeast, including *Candida albicaus, Aspergillus niger, A. fumigatus* and *Trichophytum mentagopyhtes*; the extract showed potential activity in all the strains tested and against the standard drug griseofulvin [23].

Antipyretic activity:
The ethanol extract of stalks of *N. nucifera* was evaluated for its antipyretic potential on normal body temperature and yeast-induced pyrexia in rats. The extract showed significant activity in both models at oral doses of 200 and 400 mg/kg. In the model of yeast-provoked pyrexia, the extracts showed dose-dependent lowering of body temperature up to 4 h; the results were comparable to those with paracetamol [23].

Hypocholesterolaemic activity:
The aqueous extract of lotus leaves was studied for its effects on serum lipids in a rat model. The rats were fed a high-fat diet containing 1.5% cholesterol and 1% cholic acid. Subsequent oral treatment with a crude aqueous extract of lotus leaves resulted in sharp decreases in serum total cholesterol, free cholesterol and phospholipids [23].

Anti-arrhythmic activity:
Neferine, an alkaloid isolated from the seed embryo of *N. nucifera*, has been reported to have anti-arrhythmic effects on rabbit SA nodes and clusters of cultured cardiac myocytes from neonatal rats. Neferine inhibits the slow transmembrane Na^+ and/or Ca^{2+} current of the myocardium, which leads to its anti-arrhythmic action. Neferine causes non-specific inhibition of the Na^+, Ca^{2+} and K^+ cardiac transmembrane currents in guinea-pig papillary muscles and atria, which relates to its anti-arrhythmic activity [23].

Anti-fertility activity:
The petroleum ether extract of the seed has been reported to possess anti-fertility activity in female albino mice – at a dose of 3 mg/kg. It blocked the oestrus cycle at the metoestrus stage compared with ethyl oleate. The extract significantly reduced uterine weight and affected the oestrus cycle by blocking biogenesis of ovarian steroids [23].

Nutritional value of Lotus:
Tender rhizomes, stems and leaves of lotus are edible [35] and can be cooked along with other vegetables, soaked in syrup or pickled in vinegar [36]. Rhizomes consist of 1.7% protein, 0.1% fat, 9.7% carbohydrate and 1.1% ash [37] and exhibit mild flavour and extensively used in Chinese recipe, while stem on cooking as food and the taste like beet [38]. As home remedy, lotus leaves are useful to treat summer heat syndrome in Japan and China and used to treat obesity in China [39]. Petals of lotus are floated in soups or used as a garnish, while the stamens are used in flavoring the tea. Scientists 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 [40].

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 in appreciable quantities [41]. Seeds of N. nucifera 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 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%) [42, 43].

Pharmaceutical value: Traditional knowledge of *N. nucifera:*
Traditional knowledge reveals many medicinal uses of lotus plant. The whole plant serves as astringent, emollient, diuretic and sudorific and possesses antifungal, antipyretic and cardiotonic. Different parts of the lotus plant are useful in treatment of diarrhea, tissue inflammation and haemostasis [44]. The rhizome extract has anti-diabetic [45] and anti-inflammatory properties due to presence of asteroidal triterpenoid [46]. 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 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 [47]. Hyperlipidaemia in rodents

can be treated with lotus leaves [48]. Leaves also possess diuretic and astringent properties and help to treat fever, sweating and strangury and as styptic [49].

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 [50]. The fruits and seeds of lotus are astringent and used to treat hyperdipsia, dermatopathy, halitosis, menorrhagia, leprocy and fever [51]. Seed powder mixed with honey is useful in treating cough, while roots with ghee (melted fresh butter), milk and gold promote strength, virility and intellect. Lotus seeds have been reported to possess rich antimicrobial properties [52, 53]. 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 [54]. **Table 2**

TABLE 2: TRADITIONAL USES OF DIFFERENT PARTS OF LOTUS

Part	Traditional uses
Whole plant	Used for the treatment of liver disorders in Ayurveda. Leaves, roots and diabetes, blood disorders, antifertility, heart troubles, dysentery, eruptive fevers, indigestion and as a cardiotonic, 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 Pipasa daha (burning thirst), Raktapitta (bile-blood), Chardi (vomiting), Murccha (fainting), Hrdraoga (heart disease), Mutra Kecchra (painful discharge of urine, a class of urinary affections), Jvaratisara (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 leucorrhea 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: 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. Pharmacological activities of different extracts of rhizomes, seeds, leaves and flowers, and the compounds isolated from these extracts, have been demonstrated through numerous *in-vitro* and *in-vivo* test models.

These include antioxidant, anti-inflammatory, antimicrobial, anti-arrhythmic, antipyretic, anti-ischaemic, anti-diabetic, hypoglycaemic, antidiarrhoeal, immunomodulatory and other activities. The responsible bioactive compounds which are present in the plant belong to several groups; like alkaloids (eg. dauricine, lotusine, nuciferine, liensinine, roemerine, neferine, armepavine), flavonoids (eg. kaempferol, quercetin, leucocyanidin, leucodelphinidin, catechin, isoquercitrin, astragalin), glycosides (nelumboroside A, nelumboroside B, isorhamnetin glycoside and isorhamnetin rutinoside), triterpenoid (betulinic acid). This review described many pharmacological activities of *Nelumbo nucifera Gaertn* which will give a new direction for the establishment of novel compounds which would be beneficial for scientific research. *Nelumbo nucifera Gaertn* is an important drug of indigenous system of medicine and has been known for a number of medicinal properties in Ayurveda but still its pharmacological potential has not been fully explored. This review tried to provide scientific basis for the further development of pharmacological activities of *Nelumbo nucifera Gaertn.*

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