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Lotus: An illustrative review on various pharmacological activities of *Nelumbo nucifera* (whole plant)

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ABSTRACT
Lotus and sacred lotus are two frequent names for *Nelumbo nucifera*. It refers to the Nelumbonaceae family of watery leguminous plants. The plant's roots remain embedded in the muddy bottoms of the waterways. People in all over the world employed *N.nucifera* in conventional healer for its immense health benefits. Lotus is considered as traditional remedy in different parts of the world for its enormous health benefits.It has various pharmacological activities. The pharmacological studies of lotus plant showed many ventures such as antioxidant, anticancer, antidiarrhoe, antiviral, hepatoprotectivity, anti-obesity, cardiovascular, anti platelet, neuropharmacology, psychopharmacology activities.

I. INTRODUCTION
Lotus and sacred lotus are two frequent names for *Nelumbo nucifera*. It refers to the Nelumbonaceae family of watery leguminous plants. The plant's roots remain embedded in the muddy bottoms of the waterways. The leaf of lotus is 60cm in diameter and float on the water's surface[1].*N.nucifera* has pink, red, or white blooms and is found across Asia and Oceania, but *N. lutea* has flowers which colored yellow and found throughout Northern America and Southern America. *N. nucifera* is an watery perennial plant which called the lotus, bean of India lotus of India, Chinese water lily, and holy lotus. People in various parts of the world employed*N.nucifera* in conventional healer for its immense health benefits. It has used to medicate sunstroke, diarrhoea, dysentery, haemorrhoids, dizziness, blood vomiting, uterine bleeding problems, promoting conception, improving skin condition, regulatory burning sensation, infections, cough, hypertension, fever, urinary problems, hematemesis, epistaxis, hemoptysis, hematuria, and metrorrhagia[2].

Taxonomic Classification [3]
Kingdom: Plantae – Plants;
Sub Kingdom: Tracheobionta – Vascular Plants;
Super Division: Spermatophyta – Seed Plants;
Division: Magnoliophyta – Flowering Plants;
Class: Magnoliopsida;
Subclass: Magnoliidae;
Super order: Protaenae;
Order: Proteales;
Family: Nelumbonaceae– Lotus Family;
Genus: Nelumbo Adans – Lotus;
Species: Nelumbo nucifera Gaen. – Sacred lotus.

Physical Characteristics and Description
The watery rhizomatous plant Nelumbo nucifera has a thin, elongated, creeping stem with nodal roots. Lotus is the perennial plant that has airborne in insertion to buoyant round leaves. Ethereal leaves are cup-shaped, whilst buoyant leaves are flat. Its petioles are long and tough, with prominent prickles. Flowers range in colour from white to rose, are pleasantly sweet-scented, solitary, and hermaphrodite. The flower is ovoid and glabrous, with an average diameter of 10–25 cm. Fruit that contains seeds, is black in colour, rigid and ovoid, and is organised in whorls; seeds matured and were discharged in conclusion of pod bending down to the water. The tuberous roots are 8 inches long and 2 inches wide. The smooth

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exterior layer of lotus root is green in colour; nevertheless, the interior half has several large air pockets that traverse the length of the tuber and aid in floating in the watery system[4].

CHEMICAL CONSTITUENT

There are so many types of chemical constituent which are separated from the parts of *Nelumbo nucifera*. They are:

a) **Seeds and fruits** – The *N.nucifera* seeds contain protein, fat, starch, tannin and asparagin [5].The seed is divided into three parts: the integuments, the plumule, and the cotyledons, which account for 3.74 %, 3.03%, and 93.23% of total respectively. On average, 100 seeds weigh 87.35g. sodium (1.00 %), magnesium (9.20%) Chromium (0.0042%), potassium (28.5%), copper (0.0463 %), zinc (0.0840%), manganese (0.356%), calcium (22.10%) and iron have all been discovered in Nelumbo seeds (0.1990 %). Other essential nutritional elements are total ash (4.50 percent), moisture (10.50 percent), crude carbohydrate (1.93 percent), crude fibre (10.60 percent), fat (72.17 percent), and protein (2.70 percent). It contains 348.45 calories per 100 g [6].

b) **Flower** - Many flavonoids found in lotus stamens, including, nelumboroside A, and nelumboroside B, kaempferol . It contains isorhamnetin, glycosides, and non-flavonoids such as adenine, arbuti, myo-inositol, and stamen extract. [7,8].

c) **Leaves** -According to combination of liquid/gas chromatography and mass spectroscopy, the leaves enriched a maximum amount of alkaloids. The data retention and mass spectra of the principal components in the study of non-phenolic portion from leaf extract were comparable to anonaine, nuciferine, pronuciferine, N-nornuciferine (15), roemerine and pronuciferine. (+)-1(R)-coclaurine (16) and (–)-1(S)-norcoclaurine (17) are two benzylisoquinoline alkaloids (17).

d) **Rhizome** - Asian countries eat Lotus rhizomes as a vegetable. For their mineral richness, they are utilised as health foods. The tissue is densely packed with starch granules.31.2 percent starch present in fresh rhizome and has no distinct flavour or odour. When Nelumbo starch was obtained itwas differentiate to potato and maize starch for binding and disintegration Nelumbo starch was generally considered acceptable as an additive in tablet production. It observed that the alcohol of 50% (v/v) is necessary for maximal constituent extraction [9].

Cultivataion

The region is a man-made wetlands in which lotus is grown and managed like a crop. Because of their better monetary returns, rather shallow and permanently flooded wetlands used for lotus cultivation. Lotus grows naturally in ponds, and locals peoples generally remove the rhizome for personal use rather than sale, however market prices range from Rs 20/Kg to Rs 150/Kg, based on the season[10]. The fresh lotus seed can be grown. The seeds which are long-lived have extremely rigid coatings that must be packed away at the end of one before germination to represent endosperm. When maintained at 25-30° C for 24 hours, the seedling begins to emerge. Seedlings need a lot of light to build a tuber large enough to survive the first winter.Separation is different propagation methodthat may be used in winter, right before the planting season. The propagation methodshould surrounded by at least 15 cm of soil (loam) and planted in a position that preserve the growing tip from destruction caused by contact with the pot side. At the top of container, leave a area of 15 cm at least above the dirt. This opening provides water if the pot is removed from the pool and prevents the rhizome from escaping when the pot is placed in a pond.[9].

N.Nucifera used for Traditional Medicines

N.nucifera, called the lotus plant, it has been utilized long as a part of traditional Indian, Thai, Chinese, Japanese and Korean remedies, among many others, for a various medicinal purposes. To treat fever, diarrhea, sleeplessness, heat imbalance, and gastritis the entire plant are used as herbal medication. The various fragment of this watery plant species, which include leaves, stamens, flowers, petioles, seeds, and rhizomes, are usage as the conventional medicine of Chinese for over 1000 years, and the mass production of *N.nucifera* leaves for conventional medicine and industry of pharmaceutics in China now exceeds 800,000 t/year [11]. Lotus is considered as traditional remedy in different region of the world for its enormous health benefits. It is used for treatment of ailments such as infections, epistaxis, sunburn, burning sensation controlling, diarrhoea, dysentery, haemorrhoids, improving skin condition, dizziness, blood vomiting, bleeding disorders in uterine, controlling burning sensation hematemesis, cough, urinary problems, hypertension, fever, hematuria, hematemesis, hemoptysis, and metrorrhagia, among other things[12,13].

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PHARMACOLOGICAL ACTIVITIES OF *N.nucifera*

As per the study of*N.nucifera* scientifically it showed that it has different pharmacological activities such asantioxidant activity, anticancer activity. anti-ischaemic activit, hypocholesterolaemic activity, , aldose reductase inhibitory activity, hepatoprotective activity, anti-obesity activity, anti-inflammatory activity, anti-fertility activity, anti-arrhythmic activity, anti-fibrosis activity, antiviral activity, antiproliferative activity, antidiarrhoeal activity,lipolytic activity, psychopharmacological activity, diuretic activity, antipyretic activity, immunomodulatory activity, hypoglycaemic activity, antibacterial, aphrodisiac activity, anti platelet activity, cardiovascular activity, hepatoprotectiveactivity.

a) **Anticancer activity-** In vivo and in vitro, extracts and separated compounds from several sections of *N.nucifera* have anticancer action. Isoliensinine has the most potent lethal impact of the three primary alkaloids, principally through inducing triple-negative breast cancer cells undergo cell deathvia ROS production and p38 MAPK/JNK activation [14]. 7-hydroxydehydronuciferine, one of 15 chemicals identified from the *Nelumbo nucifera* leaves, strongly suppression of melanoma,gastric malignant cell andprostate growth[15].

b) **Anti inflammatory activity-** Tissue inflammation is a dangerous reaction that causes cell damage and lead to major disorders including asthma, atopic dermatitis, and rheumatoid arthritis[16]. The triterpenoid betulinic acid found in lotus rhizome has anti-inflammatory properties against edema. Carrageenan and serotonin in the paw of rat produce edema[17]. There are evidence that cytokines generated from T cells in response to antigen activation, example IL-10 and IL-4, have a role in lung inflammation and asthma[18].

c) **Antioxidant activity-**When the radicals are buildup in the body of human rises, it can cause significant oxidation, which can damages tissue and cells. As one gets older, the body declines the ability to scavenge oxidants, which has an impact on the body's regular metabolism and processes, leading to chronic illnesses or ageing responses, which can cause various types of health problems[19]. The antioxidant efficacy of alcohol and water extract of *Nelumbo nucifera* (HANN) seeds were tested in In vivo and vitro models.n vitro, HANN has DPPH (1,1-diphenyl-2 picrylhydrazyl) radical - scavenging activity (IC50 = 6.12 0.41 g/mL) and nitric oxide (NO) radical scavenging (IC50 = 84.86 3.56 g/mL) dpph radical scavenging. The effects were better than rutin, which was employed as a control. In comparison to CCl4 administration, HANN administration to Wistar strain rats at doses of 100 and 200 mg/kg body weight for four days prior to CCl4 administration resulted in a significant dose-dependent increase in superoxide dismutase (SOD) and catalase enzyme levels, as well as a significant decrease in thiobarbituric acid reactive substances (TBARS) levels in both the kidney and liver. The improvements seen with a 100 mg/kg weight of body treatment were equivalent to those with a 50 mg/kg tocopherol therapy. The seeds of *Nelumbo nucifera* carry a large scale of phytochemicals, including alkaloids, saponins, polyphenolics, and carbohydrates, all of which contribute to strong activity of antioxidant.[20].

d) **Neuropharmacological activity-** The neuropharmacological actions of N.nucifera Gaertner seed have been display in mice and rats. The extract has the impact on phenobarbitone sodium motor coordination, anxiolytic activity, reduced time of sleeping and sleeps delay, locomotor activity, and cerebral activator was investigated. The extract also exhibited considerable depression in typical behavioral tests in a dose-related manner[21].

e) **Psychopharmacological activity-** Neferine, found in embryonic of lotus seed, could have antidepressant properties. Its anti-mobility effects in a forced swimming test 94 were assessed in mice. Neferine a hydroxytryptamine (S-HT) 1 direct metabolite. It's a receptor agonists that can decrease S-HT reuptake while also activating S-HT metabolism. It has a similar effect to imipramine and maprotiline[22].

f) **Antidiarrheal and Antidermatophytic activity -** The antidiarrheal action of seedof lotus oil was investigated, and disc diffusion revealed that it aggressively inhibited bacteria such as Escherichia coli, Shigella sp., Pseudomonas sp., Salmonella sp., Staphylococcus aureus, and Klebsiella. With the concentration of 25mg/ml of extract, the inhibitory action of oil of lotus seed was employed against dermatophytes such as Trichophyton mentagrophytes, Malassezia furfur, and Trichophyton rubrum[23]

g) **Hepatoprotective Activity-** In an in vivo study, ethanol extracts from seeds of lotus were develope to exhibit hepatoprotective properties against the cytotoxicity of carbon rats. The body

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temperature drops for 3 hours after a 200mg/kg dosage of extract is applied, whereas the temperature drops up to 6 hours when a 400mg/kg dose is applied[24].

h) **Antibacterial activity**-Lotus seeds carry polyphenols, which are secondary metabolites of complex phenols. These have potent antibacterial and antimicrobial properties. These are the same as the polyphenols found in tea[25].

i) **Antiarrythmia** –Neferine and Dauricine, two phytochemicals derived from *N.nucifera* seed, have a cardiovascular pharmacological action. The Na+K+ and Ca+2 cardiac transmembrane currents were inhibited by phytochemicals from N. nucifera. In rabbits, it has acardiac dysrhythmia medicationsand strongly suppresses platelet aggregation[26].

j) **Hypoglycemic activity-** When compared to other control animals, a rhizome extract of methanol significantly reduce blood sugar levels in normal, Streptozotocin-induced, and glucose-fed hyperglycaemic diabetic rats. This perform to show that lotus has a hypoglycemic impact when taken orally[27].In diabetic rat glucose fed hyperglycemic and streptozotocin was induced , the impact of an extract of rhizome of *N. nucifera* by ethanol was investigated. Glucose tolerance was enhanced by using the extract. Similarly, the extract has potentiating effect on exogenous insulin. In sick and normal rats, the extract's antidiabetic potential was compared to that of tolbutamide was showed to be equivalent[28].

k) **Antiaging**-The*Nelumbo nucifera* seed extract includes an antiaging substance that helps in minimizing symptoms which are elasticity loss, acne, pores, blemishes,wrinkles, fine lines etc. Formulations with powerful antiaging agents are kept in a suitable vehicle. It increases the texture and facial appearance of youthful skin. Lotus and green leaves of tea mixed in several emulsions displayed a synergistic antiaging effect, according to the findings. Both herbal plants' active ingredients with activity of antioxidant have good impact on the skin's surface, promoting both plants as the future of new antiaging treatments.[29]

l) **Anti-Obesity and hypolipidemic activity-** The*Nelumbo nucifera*extractionby using solvent as ethanol has been display to suppress adipogenesis and to have a favourable impact in reducing adipose tissue weights and modifying blood leptin levels fed a high diet of fat in rat. It also improved the profile of lipid intake in the blood[30]. The antiobesity effectiveness of active components obtained from lotus leaves i adipose tissue via induced lipolysis in mice.Flavonoids like catechin, astragalin, quercetin, hyperoside, and isoquercitrin showed lipolytic activity in visceral adipose tissue. [31].

m) **Immunomodulatory activity**-The alcohol and water extracts of seeds and rhizomes have immunomodulatory action. The extracts were said to have a stimulating impact on the immune system by altering immunological parameters. At the time of immunomodulation, the portions of plant of lotus are also beneficial[32]. Lotus seeds aid in biological functions and also include a variety of active factors and glycoproteins that stimulate human T, NK,B cells, producing cytokines and complement, and therefore improving immunity[32].

n) **Analgesic activity**-The analgesiceffect of white and red lotus seeds on Albino rats was examined by Vikrama Chakravarthy P et al. (2009). The totalnumber of 48 adult Sprague Dawley rats was separated into six groups. The findings of the experiment demonstrated that the extract of lotus seed had analgesic properties. The higher dosage group, which received 600mg/kg of white lotus seeds, showed more dramatic action. The analgesic impact can be assessed by decreasing prostaglandin cyclooxygenase synthesis[34].

o) **Gastrointestinal activity-** Probiotics are a type of bacteria that aids in the management of the human gastrointestinal system, such as the digestion and absorption of food. Lotus seeds in the multiplication of probiotic bacteria. The impact of starch of seed of lotus on bifidobacteria growth is similar to isomalto oligosaccharide[35]. Absorption issues and gastrointestinal motility include functional dyspepsia, diarrhoea, constipation, and other gastrointestinal problems. Dietary supplements are being developed, while novel lacticinia such as milk and fermented lotus seeds are being created. It has the potential to regulate gastrointestinal motility[36]. From the lotus seed the fermented milk obtained which assist to control intestinal flora, boost intestinal immunity, and preserve the mucosal barrier of GI [37].

p) **Anti-ischaemic activity -** Fromthe deserted rat heart, the *N.nucifera* seeds shows powerful anti-ischaemic properties. The quantity of extract from seed that was effective against ischaemia in the detached rat heart was determined by blood pressure, coronary flow, monitoring cardiac output, aortic flow, and monitoring cardiac output at dosages ranging from 0.1 to 30 mg/ml. Although cardiac output was equal following treatment with 10 or 3 mg/ml dosages (63.5 3.2 and

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65.8 4.0 ml/min, respectively), maximum recovery was obtained with 10 mg/ml of dose. As a result, the optimal dosage for Myocardial ischemia in the rat was discovered to be 3 mg/ml. Through calcium antagonistic actions, *N.nucifera* extract possesses specific anti-ischemic benefits[38].

q) Antiplatellet activity- The extract of Nucifera flowers obtained from water and ethanol extraction process and it was investigated at various doses (100-500g/ml) for antiplatelet activity using platelet-rich plasma. The antiplatelet action of *N.nucifera* flower extracts was dosedependent, with maximal activity at 500g/ml concentration; platelet aggregation was prevented at half the rate of normal aspirin[39].

r) **Diuretic activity**- The rhizome of*N.nucifera* has shown diuretic properties. At dosages of 300, 400, and 500 mg/kg, the methanol extraction of lotus rhizome caused substantial diuresis in rats. With Na+ and Clexcretion, it was dose-dependent rise in urine volume, which was followed by considerable K+ excretion. The urination volume increased at a lower rate than with the usual diuretic Furosemide (20 mg/kg). Although chloruretic and natriuretic activity increased significantly, natriuresis was more than kaliuresis [40].

s) **Antiviral activity**- Herpes simplex virus-1 (HSV-1) replication was greatly inhibited by an ethanolic extraction of the Nucifera seed (100 mg/ml), with IC50 of 50 mg/ml. Furthermore, HSV-1 is inhibited through sub-fraction of *N. Nucifera* (NNFR). NNFR suppressed HSV-1 reproduction up to 85.9% in HeLa cells at a dosage of 50 mg/ml, reducing acyclovir-resistant HSV-1 propagation[41].

t) **Reduction of Pulmonary Fibrosis** - Isoliesinine, which is extracted from seeds, can prevent bleomycin-induced fibrosis of lungs in rats. Inflammatory mediators were also lowered as a outcome of the protective impact[42]. The inhibitory impact of neferine on amiodarone-induced lung fibrosis. It had this impact its anti-inflammatory properties.[43]

II. CONCLUSION

The plant *Nelumbo nucifera* belonging to family Nymphaeacea has gain importance due to medicinal, nutritional, & historical values. It has many bioactive compounds such as antioxidants, flavonoids, alkaloids etc. The pharmacological studies of lotus plant showed many ventures such as anticancer, antioxidant, antidiarrhoel, antiviral, hepatoprotectivity, anti-obesity, cardiovascular, anti platelet, neuropharmacology, psychopharmacology activities. It too used in skin diseases, bleeding disorder, diabetes, skin agning etc as mentioned in traditional use of medicine of this plant. As lotus plant contain many types of chemical constituent, so it gain great importance in pharmaceutical use.

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