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Review of Pharmacological Evaluation of Neuroprotective Potential of Nelumbo nucifera (Red Flower) Extract in Experimental Alzheimer's Disease in Rats

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Abstract:

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline, memory impairment, oxidative stress, and cholinergic dysfunction. In recent years, natural products and phytochemicals have gained increasing attention for their neuroprotective potential against AD pathology. This review highlights the pharmacological evaluation of the neuroprotective activity of Nelumbo nucifera (red flower) extract in experimental models of Alzheimer's disease in rats. Nelumbo nucifera, commonly known as the sacred lotus, possesses a rich phytochemical profile including flavonoids, alkaloids (nuciferine), phenolic compounds, and antioxidants that contribute to its neuroprotective effects. Experimental studies have demonstrated that treatment with N. nucifera extract attenuates oxidative stress, inhibits acetylcholinesterase activity, enhances antioxidant enzyme levels (SOD, CAT, GSH), and reduces lipid peroxidation (MDA) in the brain. Behavioral studies using the Morris Water Maze and Y-Maze tests indicate significant improvement in spatial learning and memory retention. Histopathological findings support its ability to prevent neuronal degeneration and amyloid beta deposition. The neuroprotective mechanism is attributed to its antioxidant, anti-inflammatory, and cholinesterase-inhibiting properties. Therefore, Nelumbo nucifera (red flower) extract represents a promising natural therapeutic candidate for the management and prevention of Alzheimer's disease, warranting further investigation at molecular and clinical levels.

Keywords: Nelumbo nucifera; Neuroprotection; Alzheimer's disease; Acetylcholinesterase inhibition

Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by a gradual decline in cognitive functions such as memory, reasoning, and behavior, ultimately resulting in functional dependence and death. It is the most common cause of dementia, accounting for approximately 60–70% of all dementia cases worldwide.[1]

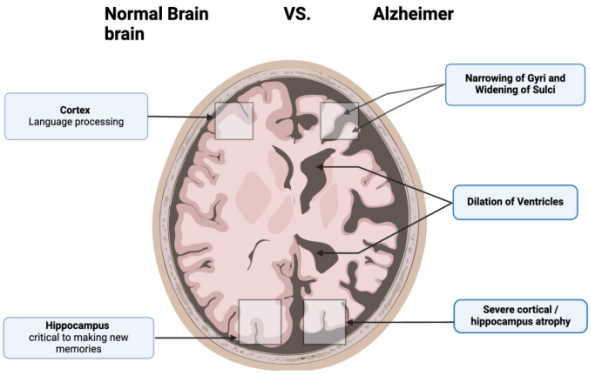

Figure 1: Normal Brain and Alzheimer

Pathophysiology of Alzheimer Disease

Alzheimer's disease (AD) is a multifactorial neurodegenerative disorder characterized by progressive synaptic dysfunction, neuronal loss, and cognitive impairment. The underlying pathophysiology involves a complex interaction between genetic, molecular, and environmental factors**,** leading to accumulation of abnormal proteins, oxidative stress, and neuroinflammation.[2]

Plant Profile

Nelumbo nucifera Gaertn. is a well-known aquatic medicinal plant commonly referred to as the Sacred Lotus or Indian Lotus. It has a wide range of synonyms based on regional and traditional systems of medicine.[3]

Figure 2: Flower of Nelumbo nucifera

Table 1: Taxonomical Classification:

Taxonomic Rank	Classification
Kingdom	Plantae
Subkingdom	Tracheobionta (Vascular plants)
Division	Magnoliophyta (Flowering plants)

Class	Magnoliopsida (Dicotyledons)
Order	Proteales
Family	Nelumbonaceae
Genus	Nelumbo
Species	Nelumbo nucifera Gaertn.

Climate and Geographical Distribution[4]:

The plant is native to Asia, particularly India, China, Japan, Sri Lanka, and Vietnam, but it has naturalized in Australia, Egypt, and parts of North America. In India, it is cultivated extensively in states such as Tamil Nadu, West Bengal, Uttar Pradesh, and Odisha.

Botanical Description[5]

Nelumbo nucifera is a perennial aquatic herb characterized by a rhizomatous stem that grows horizontally in muddy soil and produces large, orbicular leaves and showy pink or white flowers.

Table 2: Key phytoconstituents [6]

Plant Part	Major Phytochemicals
Flowers	Quercetin, Kaempferol, Isorhamnetin, Nuciferine, Neferine, O-nornuciferine, Liriodenine
Leaves	Catechin, Myricetin, Isoquercitrin, Rutin, Luteolin
Rhizomes	Polyphenols, β-sitosterol, Palmitic acid, Linoleic acid, Vitamin C
Seeds	Nuciferine, Neferine, Liensinine, Flavonoid glycosides, Proteins
Stamens	Neferine, Anonaine, Armepavine, Norarmepavine

Pharmacological Activity[7-9]

1. Antioxidant activity:

Methanolic and ethanolic extracts of N. nucifera flowers and leaves exhibit strong DPPH, FRAP, and ABTS radical scavenging activities due to the presence of phenolic compounds.

2. Anti-inflammatory activity:

Extracts inhibit COX-2, TNF-α, and NF-κB pathways, suppressing microglial activation and neuroinflammation.

3. Antidiabetic and anti-obesity activity:

Leaf and seed extracts improve insulin sensitivity and lipid metabolism by modulating PPAR-γ and AMPK pathways.

4. Cardioprotective and hepatoprotective activity: The rhizome and seed extracts protect against isoproterenol- and CCl_4-induced oxidative damage, improving antioxidant enzyme levels.

5. Anticancer potential: Flavonoids and alkaloids from the petals induce apoptosis in human cancer cell lines by activating caspase pathways.

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