



## A review on the neuroprotective effect of *Nelumbo nucifera* seed pod

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### Article History:

Received on: 14.03.2019

Revised on: 06.06.2019

Accepted on: 10.06.2019

### Keywords:

Receptaculum  
Nelumbinis,  
neuroprotection,  
quercetin,  
memory enhancement

### ABSTRACT

Receptaculum Nelumbinis, the dried seed pod of *Nelumbo nucifera*, exhibited good efficacy for improving learning and memory abilities. Earlier, studies revealed that Receptaculum Nelumbinis can exert therapeutic effects in diverse disorders like heart failure, neoplasm via anti-oxidative, anti-inflammatory and anti-proliferative activities. In the central nervous system (CNS), Receptaculum Nelumbinis (RN) also has beneficial effects on various disorders, such as Alzheimer's disease (AD), depression, Parkinson's disease (PD), cerebral ischemia, epilepsy, and Huntington's disease (HD). RN also enhances memory and cognition ability of rodents in dissimilar pathological conditions, such as stress exposure, diabetes, aging and high-fat diet (HFD). The effect of noise stress on exploratory, locomotor, and anxiolytic activity in the open-field behavior (OFB) test and the effect of drug RN and active component quercetin, a flavonoid isolated from seedpod in overcoming these changes. Optimistically, getting a vibrant impression concerning the role of RN in the CNS, the present paper summarizes and discusses the pharmacological effects of RN as well as its possible mechanisms in CNS disorder prevention and or therapy.



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ISSN: 0975-7538

DOI: <https://doi.org/10.26452/ijrps.v10i3.1469>

Production and Hosted by

IJRPS | <https://ijrps.com>

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### INTRODUCTION

In Chinese, Receptaculum Nelumbinis is also known to be "Lianfang", which came from the dried receptacle (seedpod) of *N. nucifera* and it is normally used as conventional Chinese medicine. It has been used as an antihemorrhagic agent particularly for

excess menstrual hemorrhage and unbalanced genital bleeding as well as it is considered as a medicine for dehydration produced by diarrhea in summer and for deterrence of miscarriage.

Receptaculum Nelumbinis possess large quantities of phenolic compounds, but it has also shown an extensive spectrum of biopharmacological effects, comprising anti-tumor effect, anti-oxidative effect, defensive effects in contradiction to experimental myocardial injury and ischemia, improving learning and memory abilities, and radioprotective activity as reported in the earlier studies (Wu, 2011; Gong *et al.*, 2008; Zhang *et al.*, 2004; Duan *et al.*, 2010).

Seed pod contain hyperoside, isoquercitrin and quercetin-3-O- $\beta$ -D-glucuronide exhibited structure-activity and effective activity relation analysis directed towards the catechol group affecting the antioxidant activity, which all improves the brain disorder (Chowdary and Sirishchowdary, 2013).

### Neuroprotection by RN antioxidants

In vitro, antioxidant assays propose that the antioxidant potential of *Receptaculum nelumbinis* is strong and might have been potentially used as a safe and inexpensive bioactive source of natural antioxidants. NN is a flavonoid-rich plant that contains kaempferol, quercetin, isorhamnetin and myricetin.

Furthermore, on the H<sub>2</sub>O<sub>2</sub>-induced impairment of human umbilical vein endothelial cells, the lotus seedpod extracts demonstrated considerable dose-dependent protective effects. Amid, lotus seedpod extracts indicated comparatively tougher cell-based antioxidant enzyme activities and lesser contents of nitric oxide and malondialdehyde.

The neuroprotective activities of dietary flavonoid have potentials to protect neurons in contradiction to damage induced by neurotoxins, which is a capability to overturn neuroinflammation, and the prospective to uphold learning, cognitive and memory function. The previous study proved the beneficial effect of NN seedpod on the effect of noise stress on exploratory, locomotor, and anxiolytic activity in the open-field behavior (OFB) test.

### Role of RN on brain functions

Based on the findings from various parts of *Nelumbo nucifera*, this has to be noted that seed pod may also have an increasing effect on memory. The cognitive-enhancing effect of seed pod on Alzheimer diseases, Parkinson's disease using spatial memory and learning function test were noted. In mice, the effect of lotus seedpod showed better brain function on scopolamine-induced amnesia, by means of the Morris water maze test and passive avoidance test in respect to glutamate-induced cell death.

The seed pod of lotus increases memory and learning deficits, that reduces scattered senile plaques, and ameliorates mitochondrial dysfunction, as shown by the reestablishment of mitochondrial membrane potential and reactive oxygen species as well as ATP levels of mitochondria isolated from the hippocampus.

### Effect of RN on memory impairment

In the Morris water maze test, when the platform is concealed for the mice, spatial learning, as well as long-term memory function, can be resolute by measuring frequent training trials in which the rat has to discover a platform, which is monitored in a probe trial by determining inclination for the platform quadrant. We established that seed pod of Lotus significantly diminished escape latency and augmented the time spent in the target quadrant, in contrast with scopolamine treated group.

The results specify that, in a scopolamine-induced dementia mouse model, the seed pod of lotus improves spatial learning and memory. Additionally, seedpod of lotus abridged escape latency day to day, signifying that ENS also increases reference or long-term memory.

### Effect of RN on Cognitive function

In aged-impaired (AI) animals, when Lotus seed pod supplementation was given for 7 weeks, the result significantly diminished iNOS activities and enhanced hippocampal nNOS phosphorylation status. These results recommended that, in AI animals, changes in the NO system may comprise ameliorative effects of seedpod on cognitive deficits (Xu *et al.*, 2011). It has to be noted that quercetin liposomes through nasal direction significantly enhanced memory impairment by constraining the oxidative damage in the hippocampus, with a reduced level of MDA though it increases the activity of SOD, glutathione, and catalase (Prasad *et al.*, 2013).

In Morris water maze model, Quercetin isolated from RN showed significant development in scopolamine impaired performance concerning retention and acquisition of memory in working and spatial memory tests, that improved step-down latency in passive avoidance paradigm, increased locomotor activity and improved grip strength in Rotarod test (Woodside *et al.*, 2004).

The quercetin, the active component in higher doses reduced AChE activity significantly, and that results in the intensification of accessible acetylcholine, a neurotransmitter, that play a vital role in memory and learning process and it also increases of neuron density (Sriraksa *et al.*, 2012).

Many previous finding demonstrated that in addition to the antioxidant properties of quercetin, it also enhanced spatial memory impairment among the 8-arm radial maze task and neuronal loss in the hippocampal CA1 area; thus the proof directs that quercetin may possibly possess the ability to augment memory done by the intonation of signal cascades (Kelsey *et al.*, 2010). Chronic quercetin administration significantly upturned reserpine-induced retention deficits. It has also significantly inverted the reserpine-induced reduction in brain SOD and catalase levels among mice.

It was designated that quercetin had a protective role in contrast to the reserpine-induced orofacial dyskinesia and memory impairment (Naidu *et al.*, 2004). Quercetin improved cerebral blood flow (CBF) laterally by preventing memory impairment, oxidative stress, cholinergic dysfunction

and reformed brain energy metabolism instigated by STZ in mice (Tota *et al.*, 2010). The quercetin-treated group was significantly improved by the activity of AMP-activated protein kinase (AMPK) (Chen *et al.*, 2014).

### Effect of RN on aging disorders

Xu *et al.* (2010) found that, by the stimulation of extracellular signal-related kinase signaling pathway, lotus seedpod supplementation for 7 weeks improves cAMP-response element-binding-dependent transcription that contributes to it, and it has confirmed improving effects on cognitive deficits in aged impaired animals. Yin *et al.* (2016) have established that keeping neurons under toxin exposure diminished cell viability significantly and augmented the quantity of apoptotic cells, where lotus seedpod proanthocyanidins (LSPCs) palpably protected the hippocampal neurons in contrast with brain cell damage.

Likewise, a definite concentration of lotus seedpod repressed the advancement of Ca<sup>2+</sup> level as well as intracellular reactive oxygen species (ROS), and it also prohibited the disruption of mitochondrial membrane potential induced by toxin exposure. Moreover, supplementation of seedpod diminishes DNA damage, restrict cell cycle arrest at S phase, and prevent cell death and necrosis of hippocampal neurons. Trough constraining mitochondrial apoptotic pathway and oxidative stress, LSPCs get protected against rotenone-induced neurotoxicity (Yin *et al.*, 2016).

By progressing the antioxidant defense ability of brain, colon and serum, amending brain cholinergic activity, and reducing the oxidative damage of serum as well as brain and its nNOS mRNA level, LSPC promoted the memory-enhancing effect. And this combination provides a feasible therapy in the handling of memory impairment in aging process and some associated disorders like AD.

### CONCLUSION

A combined source of knowledge concerning the pharmacological effects of RN in the CNS has been shown in the present literature. Thus, the paper summarizes and discusses the pharmacological effects of RN as well as their possible mechanisms in the prevention and/or therapy of disorders afflicting the CNS disorders.

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