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Pharmacognostic and Pharmacological Potential of *Bacopa monnieri*

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ABSTRACT: The risk of developing a neurodegenerative disease such as Alzheimer's, Parkinson's, or Huntington's disease increases dramatically as people get older. Although therapy can help with some of the physical and mental symptoms of neurodegenerative diseases, there is currently no way to stop the disease from progressing. It's important to investigate ayurvedic medicinal plants in order to maximize their capacity for improving human health. Ayurvedic medicinal herbs and herbal products normally provide relief even after long periods of use with no significant side effects. *Bacopa monnieri*, also known as 'Brahmi,' is a plant that belongs to the Plantaginaceae family and is known for its revitalising and nootropic properties, as it enhances memory and intellect. Herbs like brahmi (*Bacopa monnieri*) may have antioxidants, delay dopamine depletion, and induce proper protein development, according to ethnobotanical proof (neuroprotective properties) and also have protective potential in other various organs.The herb has shown no major psychological, neurological, haematological, or vital organ damage in certain toxicological studies. This review focuses on *Bacopa monnieri*, a potentially useful medicinal plant. As a result, the aim of this review is to collect current and detailed knowledge on *Bacopa monnieri*, with a focus on phytochemical and ethnomedical uses, as well as scientifically reported pharmacognostic and pharmacological practices.

KEYWORDS: *B.monnieri*, Antioxidants, Neuroprotective, Neurodegenerative disease

I. INTRODUCTION:

Bacopa monnieri has been used medicinally by Ayurvedic doctors, followers of the traditional Indian medical system, for thousands of years. In many ancient Ayurvedic texts, including the Caraka Samhita and the Sushruta Samhita, Bacopa was chronicled first. *B.monnieri*is a creeping plant found in humid, marshy wetland areas, including those of the Indian subcontinent, East Asia, Australia, and the United States, and is also known as water hyssop, Brahmi, Bramabhi, and nirabarhmi. Bacopa has white to light purple flowers and small leaves, and over 100 species of the plant are included in the genus Bacopa[1]. It belongs to the Plantaginaceae family which grows in wetland near marine freshwater sites up to 1500 height [2]. It is a renowned Indian medicinal plant which has been used in the Ayurvedic medicinal system for more than 3000 years as a memory booster[3].

B.monnieri has been used as a memory and learning enhancer, sedative, and anti-epileptic in Ayurvedic medicine for decades, either alone or in combination with other herbs. It has attracted the attention of phytotherapists and pharmacologists, and it has been shown by an Australian study to be one of the most common memory aids among 60-64-year-old consumers there [4]. This plant is well known for its brain function enhancement along with memory enhancement, neurodegenerative, antioxidant, anti-toxic, hepatoprotective, anti-hypertensive, anti-diarrheal, analgesic, anti-ulcer, anti-bacterial, anti-fungal, anti-cancer, anti-oxidant, anti-inflammatory, anti-depressant and anti-epileptic[5].The herb Bacopa, also known as the nootropic herb, helps to repair damaged neurons, synthesize neurons and restore synaptic activity, and improves brain function. B. Monnieri contains brahmine alkaloids, nicotinic acid, herpesticides, bacosides A and B, saponins A, B and C, triterpenoid saponins, stigmastanol, beta-sitosterol, betulinic acid, D-mannitol, stigmasterol, alpha-alanine, aspartic acid, glutamic acid, serine and pseudojujubogenic glycosides[3]. This herb acted as a bloodstream mental chelating agent which any excess of toxic metals can be removed. It is also used in phyto-remediation to eliminate heavy metals such as chromium and cadmium [6].

The population of the planet is rapidly ageing. An increased incidence of chronic, age-related diseases and disorders involving oxidative stress and low-level chronic inflammation is one

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effect of an aging population. A rise in age, including Alzheimer's disease (AD), and other prevalent neurodegenerative disorders, is a significant risk factor for dementia. *Bacopa monnieri* can serve as a dietary antioxidant, with many modes of action to protect the brain from oxidative damage and cognitive impairment associated with age. Several studies have shown that *Bacopa monnieri* improves cognitive function, particularly in older people, using the standardized extract [7]. It also decreases not only hippocampal β-amyloid deposition, but also hippocampal damage caused by stress[8].

Clinical trials suggest that formulations based on bacopa have beneficial effects on the reconstruction of mental functions in children with attention deficit hyperactivity disorder (ADHD) and lead to the recovery of cognitive functions in patients with stroke and epilepsy[6]. Additionally, *B.monnieri* in the gastrointestinal tract has also been shown to cause side effects, i.e., nausea, increased stool frequency and abdominal cramps. After taking several Ayurvedic herbs, including *B.monnieri* , severe liver toxicity was reported in a woman taking *B.monnieri* for 9 months, but her liver function returned to normal after she stopped taking the herbs. Due to the plant possible positive ethnobotanical and pharmacological applications[9].

***Bacopa monnieri*: A Herb**

Ayurveda is often referred to as one of the oldest medical systems and has been used for more than a thousand years by Indians. Today, in the past 10 to 20 years, the use of Ayurvedic drugs has declined in India rather than in other countries due to civilisation. The theory of the Five Doctrines of Ayurveda is 1.Vagu (Air) 2. Jala (Water) 3. Akash (Space) 4.Prithvi (Earth) 5.Teja (Fire).*Bacopa monnieri* (Water hyssop brahmi) is a slippery perennial plant belonging to the Plantaginaceae family, commonly found throughout India in wet marshy and damp areas[10,11]. The plant has a very short stem on to the greeny leaves are present on it as given in Table No1. The leaves *Bacopa monnieri* are succulent, oblong, and 4-6mm thick. The flower of this plant is small, actinomorphic, and white with four to five Petals [12]. *Bacopa monnieri* has been used as medhyarasayana, a class of drugs used to treat brain functions and diseases, in different ayurvedic constitutions[13]. *Bacopa monnieri*, a name derived from Lord Brahma, the Hindu god of creation, is popularly known as Brahmi. The neuroprotective activity of the drug has been shown by some studies using the standardized CDRI08 extract. In the treatment of neurodegenerative disorders, *Bacopa monnieri* is now available as a nootropic and memory enhancer drug in the market [14].

Table No-1: Scientific Description of Plant (*Bacopa monnieri*)

***Bacopa monnieri*: SYNONYMS**	***Bacopa monnieri*: PLANT**	***Bacopa monnieri*: SCIENTIFIC CLASSIFICATION**
Bramiamonnieri, Gratiolamonnieria, Herpestismonniera, monieracuneifolia		Kingdom: Plantae Clade: Tracheophytes Order: Lamiales Family: Plantaginaceae Genus: Bacopa Species: B. monnieri

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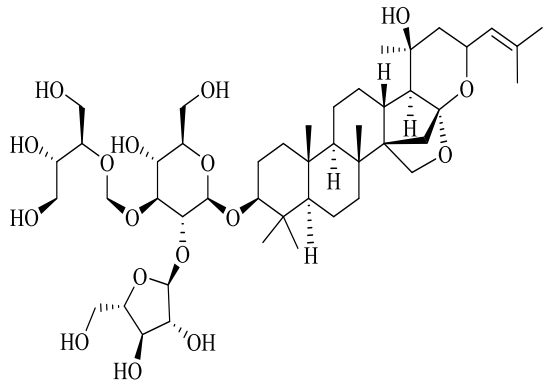
The morphological study shows that dark bluish flowers, flat & large leaves, greenish brown stem, reddish brown colored root transverse section of Bacopa floribunda have been shown by Bacopa floribunda. Epidermis, decreased cortex, parenchyma filled with minute amount of tannin content, lower amount of oil globules, phloem & its fibres, poorly arranged clumped xylem along with parenchyma & its fibers, along with large aerenchymatous cells [15].

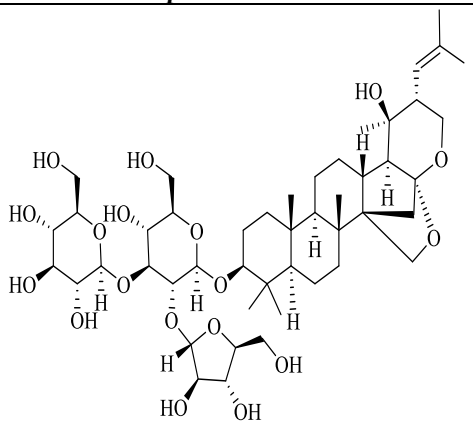
Root Morphology: The longitudinal fragments of the dried main roots, about 6-7 mm in diameter, are wrinkled and reddish brown in colour [15].

Active Constituents: These all are the main chemical constituents present in *Bacopa monnieri* are named as shown in table No 2.Bacoside A, Bacopaside II, Bacopaside I, Bacopaside X, Bacopasaponin C, Bacopaside N [16,17].

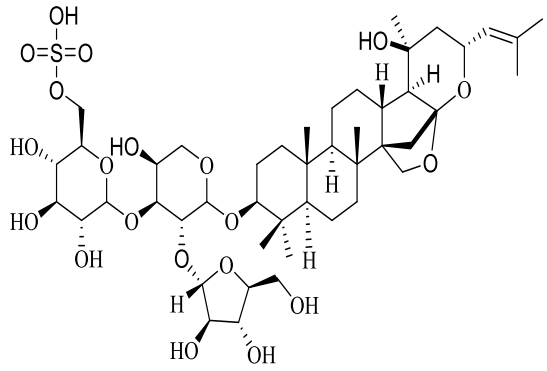
Table No.2: Active constituents Present in *Bacopa monnieri*



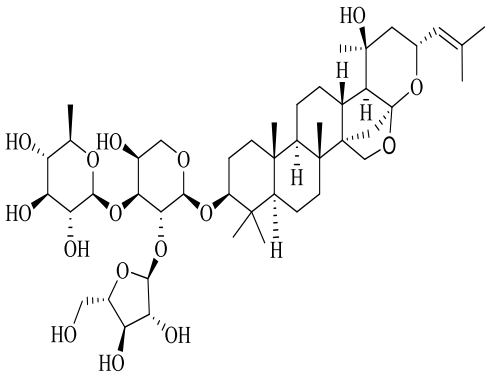
Bacopaside A



Bacopaside II



BacopasideI



Bacopaside X

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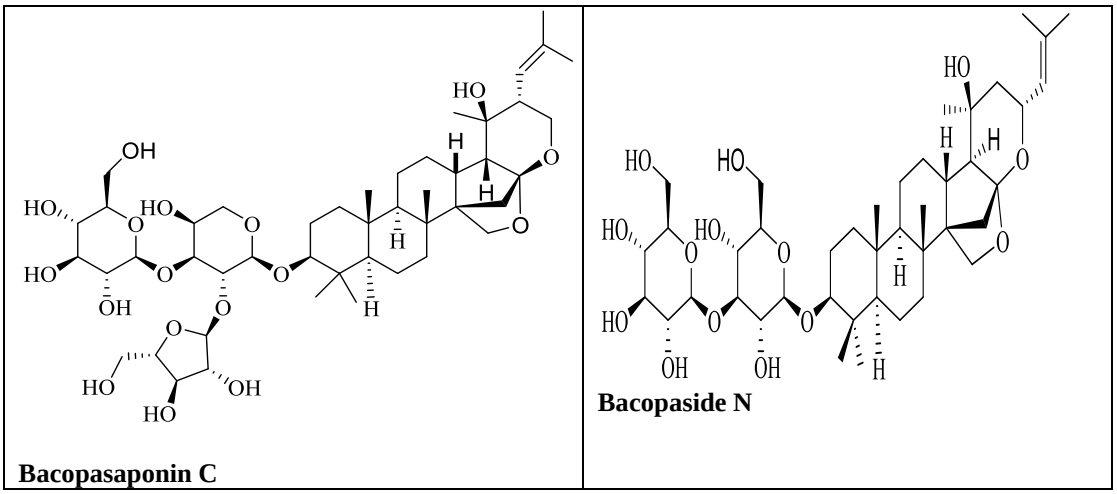

FORMULATION:

The regular doses of *Bacopa monnieri* include 5-10 g of non-standard powder, 8-16 mL of infusion powder, and 30 ml of syrup per day. Adults should take 200-400 mg daily in divided doses of Bacopa extracts standardized to 20% bacoside A and B, whereas children should take 100-200 mg daily in divided doses as given in figure No.1 [18].

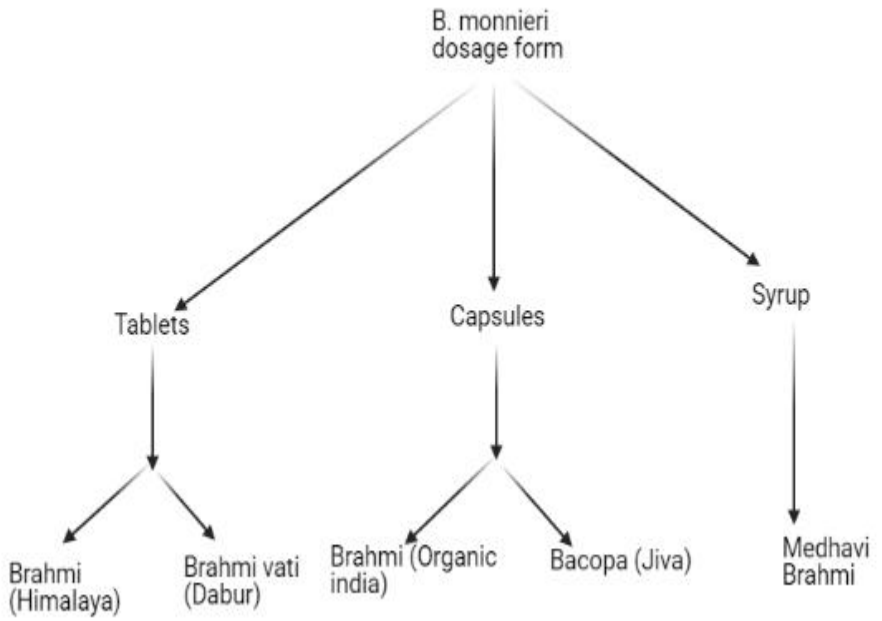

Fig. 1: Dosage form of *Bacopa monnieri*

ROLE IN CNS:

Alzheimer's disease:AD is a neurodegenerative or memory loss disorder of the brain is named after Dr. Alois Alzheimer. AD causes a progressive loss of neurons and shrinkage of the size of the brain, particularly in the cortex and hippocampus region of the brain.

In the modern era, the rise in elderly population numbers gradually increases the environmental and genetic risk factors for AD. The gene APP is on chromosome 21 and provides a

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brief trigger for β-amyloid protein [19,20]. β-amyloid is a 39-42 amino acid protein derived proteolytically from larger transmembrane proteins that is involved in the degeneration of neurons by the aggregation of β-amyloid and Tau protein [21]. Importantly, tau accumulation substantially facilitates the development of neuroinflammation and neurofibrillary tangles through the cell-to-cell spreading process throughout the brain cells as given in figure No.2 [22]. K. Iqbal et al revealed that abnormal tau hyperphosphorylation causes inhibition and disruption of microtubule-associated protein (MAP1A/MAP2B/MAP2) results in the aggregation of tau tangles in the cytosol, leading to cell death [23]. In addition, insoluble twisted fibers in the NBM (Nucleus basalis of meynert) are associated with the failure of the cortical cholinergic system, which reduces the activity of the enzyme forming Ach, resulting in the prevalence of Alzheimer's illness [24]. In an etiological context185 missense mutations in PSEN1 and PSEN2 contribute to noxious gain of function because they are associated with a relatively increased development of β-amyloid protein [25].

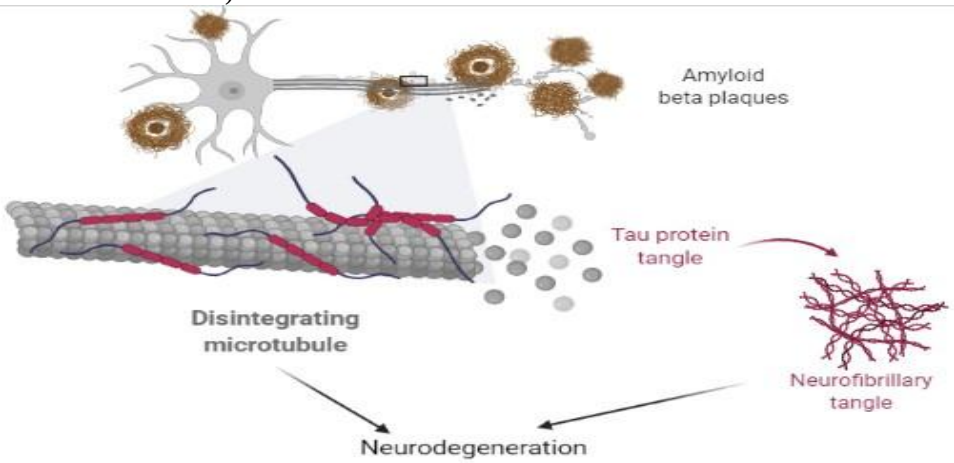

Figure No.2 Pathological markers of Alzheimer's Disease

Symptoms may include in AD: Sleep disorders, Dementia (Memory loss), Confusion with time and place, Trouble understanding visual images and spatial relationships, Disorientation, Delusion and Inability to create new memories [26].

Parkinson's disease: Parkinson's disease is a long term neurodegenerative, neurological disease that causes a person to lose control over some body functions.

PD is characterized by dopamine deficiency, α-synuclein neuronal accumulation (a protein encoded by the SNCA gene in humans) within substantia nigra and nucleus tractussolitarius (NTS) [27]. The accumulation of Lewy neurites (a type of α-synuclein) significantly interferes with the mechanisms of cellular transport based on microtubules, leading to synaptic dysfunction, oligomerization, causing neurodegeneration by fibrillation. Therefore, the mutation of the enzyme β-glucocerebrosidase was also found to be the second hallmark risk of PD [28].Masato et al. showed that the molecular mechanism of SNpc causes neurodegeneration in PD by the catabolism of dopamine by MAO to form Toxic (DOPAL) as given in figure No.3[29].

Symptoms may include in PD: Akinesia (loss or impairment of the power of voluntary movements), Tremors (Involuntary shaking or movements of the body), Rigidity (Inability to be too bent), Postural instability (Unstable when standing), speech changes, and Writing changes [30].

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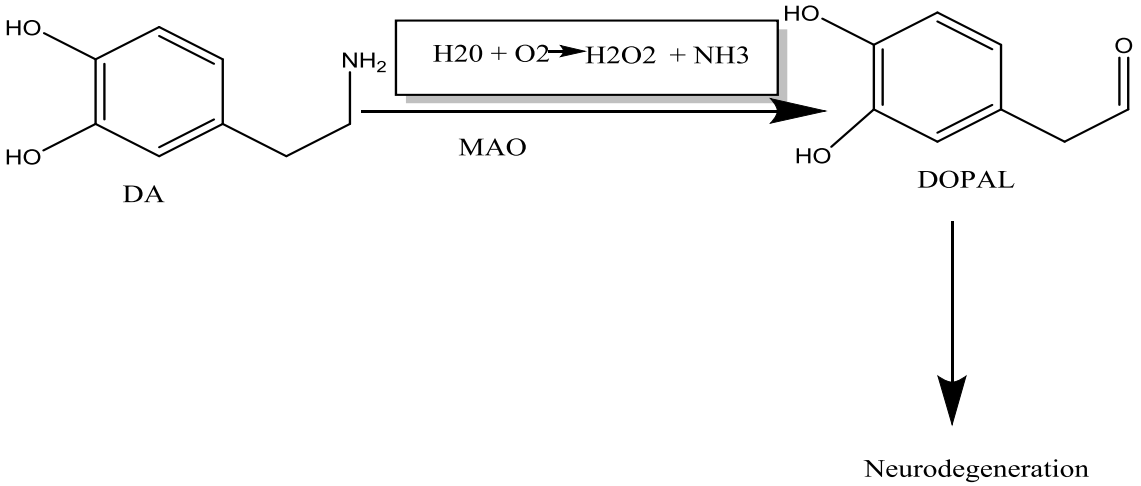

Fig No.3 Intra-neuronal catabolism of Dopamine

Huntington's disease:HD is a neurodegenerative disease in which nerve cells in the brain break down over time with choreoathetoid movement and dementia.HD is an autosomal dominant disorder characterized by the amplification (more than 36 repetitions) of CAG trinucleotide elongation in the gene encoding Huntington's disease on chromosome number 4 [31]. In addition, in the first exons of the Huntington'sgenes (IT15), the proliferative activity of polyglutamine repeats showed an irregular functioning of protein leading to neural cell death in the brain's striatal and cortical area [32]. In fact, when there are more than 40 CAG repeats, the disorder will lead to more extreme and eventually affect the loss of striatum neurons (striatum atrophy) by expressing dopamine receptors [33].Symptoms may include in HD: Chorea (Abnormal involuntary movement and Behaviour disturbance, Impaired function, Attention judgment and awareness also affected, Stumbling and Clumsiness, Amnesia and Hallucination [34].

Amyotrophic lateral sclerosis (ALS): Amyotrophic lateral sclerosis is also known as motor neuron disease, is characterized by the degeneration of both upper and lower motor neurons, which leads to muscle weakness and eventual paralysis.ALS is characterized by the loss of motor neurons (UMNs and LMNs) and the ventral horn cell of the spinal cord by increase in inflammation and activation of microglia which normally responds to neural damage and removes the damaged cell by phagocytosis [35]. Consequently, two other characteristics of ALS are the misfolding of Prions (protein infectious agents) with neuron loss and death ability, and the second is the excitoxicity of glutamate, resulting in excessive activation of receptors, allowing a high influx of ca2+ into cells to cause a variety of enzymes that destroy the genetic material of the cells, such as phospholipase, proteases and endonucleases as given in figure No.3 [36, 37]. Therefore, a recent study found that seven ALS-causing genes are MATR3, CHCHD10, TBK1, TUBA4A, NEK1, C21orf2, and CCNF, which are associated with protein aggregation, leading to damage to the genetic material of the cell [38].Symptoms may include in ALS: Slurred speech, Muscle twitching, Difficulty watching, Muscle cramps and Respiratory depression [39].

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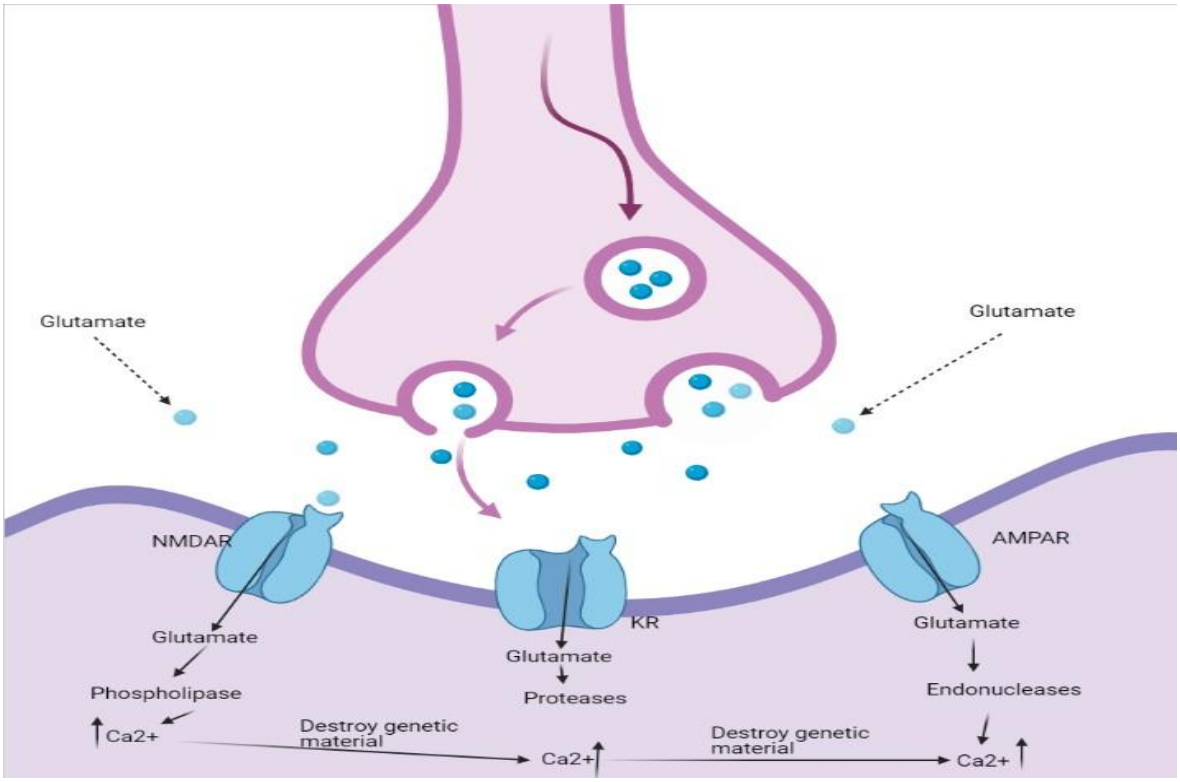

Fig No.4 Glutamate Excitotoxicity

NEUROPROTECTIVE ACTIVITY OF HERB:

- ***Bacopa monnieri*on Dopamine:** According to the author dopamine is a neurotransmitter produced in the brain that controls all motor and cognitive functions. *Bacopa monnieri* was used to pre-treat Rotenone-mediated PD experiments. Following that, monitoring of the isolation of mid brain after 20 days shows a 30% rise in dopamine levels [40]. In drosophila melanogester, *Bacopa monnieri* administration at a therapeutic dose for 7 days inhibits dopamine degradation in the upper head 33% and body area 44% [41]. Thomas et al. investigate that *Bacopa monnieri* disrupted the functions of cAMP signalling pathways that appear to work through dendrites proliferating and thus promote neuron interaction by altering the expression of Bax gene [42].
- ***Bacopa monnieri* on α- synuclein:** α-synuclein is a protein encoded by the SNCA gene that is located primarily at the tips of neurons. The authors used caenorhabditis elegans to perform an experiment in which they used 6-hydroxydopamine (6-OHDA) to trigger -synuclein aggregation [43]. According to Choudhury et al *Bacopa monnieri* activates HSP-70 protein, resulting in α-synuclein disaggregation or protein unfolding capacity. Thus, in neurodegenerative disorders, HSP-70 acts as the first modulator marker of therapeutic agents [44]. In addition, in response to neurodegenerative disease, *Bacopa monnieri* inhibits oligomerization and α-synuclein binding in the A53 gene [45].
- ***Bacopa monnieri*on memory:** *Bacopa monnieri* improves cognitive and memory functions significantly. The administration of a 600 mg dose of bacopamonnieri to the elderly population over a 12-week period improves cognitive and memory functions [46].A follow-up study with a higher single dose in a double-blinded experimental method found that *Bacopa monnieri* could improve memory capacity and retain new information [47]. In a double-blind randomised trial, S. Roodenrys et al. found that *Bacopa monnieri* improves rate of leaning in a brightness discrimination task, retention of new information, and amnesia caused by immobilisation, electroconvulsive shock, and scopolamine acting via anti-oxidant impact [48].
- ***Bacopa monnieri*on β-amyloid:** Bacopamonnieri protects the brain from β-

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amyloid damage by inhibiting cholinergic degeneration and the AChE in response to increasing ACh levels in the brain[49]. *Bacopa monnieri* also protects the brain from further damage by inhibiting Maβ-40 (a form of -Amyloid protein) and peptide fibrillation [50]. *Bacopa monnieri*'s neuroprotective function, according to Ayurvedic physicians and laborotary scientists, is attributed to the existence of an active constituent known as bacoside A [51]. Bacoside A inhibits A42 binding to each other, preventing it from causing Alzheimer's disease symptoms. Bacoside A's activity can be measured using the MTT assay [52].

- ***Bacopa monnieri* on PSEN1 and PSEN2:** Presenilin1 is a central gene involved in the early stages of Alzheimer's disease, with SNP type mutations in PSEN1 and PSEN2 causing symptoms to appear. The use of *Bacopa monnieri* stops the progression of Alzheimer's disease by inhibiting the roles of PSEN1 and two mutated genes [53, 54].
- ***Bacopa monnieri* on CAG:** CAG repeats have been shown to influence the age of disease onset in the elderly. *Bacopa monnieri* works by lowering dementia caused by CAG repeats and decreasing the development of radical oxygen species, but there is no scientifically or experimentally proved that *Bacopa monnieri* specifically blocks CAG repeats in response to HD [55].
- ***Bacopa monnieri* as an Anti-oxidant:** In HD patients, oxidative stress is one of the lethal mechanisms that contribute to the elderly phase, which leads to neurodegenerative disease or ROS-induced dementia. By the the activity of scavenging enzymes including catalase, peroxidase, and glutathione peroxidase (GPx), *Bacopa monnieri* has been shown to reduce the formation of radical oxygen speciesas given in figure No.5 [56]. In the rat brain's hippocampus, *Bacopa monnieri* aids in the regeneration of damaged neurons in a specific region of the brain and promotes neuroprotective effects against free radical oxygen organisms [57]. Furthermore, it inhibits the free radical oxygen species-induced lipid peroxidation pathway [58]. In the rat brain, *Bacopa monnieri* has been shown to protect against oxidative and cell damage caused by chronic cigarette smoking [59]. The presence of Sulfhydryl and polyphenol components in *Bacopa monnieri* contributes to its antioxidant function. These components help to scavenge ROS [60]. In rats induced by CUS, the authors discovered that *Bacopa monnieri* extract protects neurons while also damaging cells by increasing the amount of antioxidant enzymes and BDNF [61].Shinomol et al. discovered that pretreatment with *Bacopa monnieri* protects N27 cells from oxidative damage caused by ACR induced neurotoxicity [62].

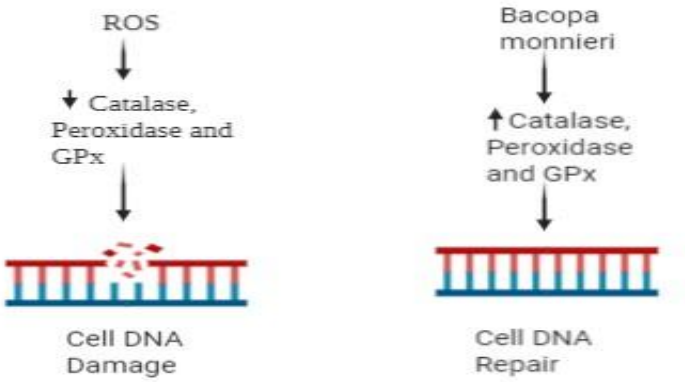

Fig.5 Anti-oxidant mechanism of *Bacopa monnieri*

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- ***Bacopa monnieri* on ALS:**

According to R Khan et al., Bacopamonnieri acts as a neuroprotectant by blocking glutamate activation after binding to the NMDAR receptor, resulting in reduced excitotoxicity of glutamate inducing enzymes such as glutamate dehydrogenase, phospholipase, protease, and endonucleases in overstimulated hippocampal neuron[63]. According to the findings, *Bacopa monnieri* acts as a neuroprotective agent by reducing overstimulation of the 5HT2C receptor, resulting in lower IP3 and ca2+ ion accumulation. In the Pilocarpine-induced model, it also reduces NMDA activity in the rodent's cerebral cortex, resulting in lower mGlu and GLAST expression [64]. M.D. Nemetchek et al stated that by inhibiting pro-inflammatory cytokines such as IL-6 and TNF-alpha from LPS-activation of microglia, *Bacopa monnieri* prevents neuronal failure [65].

OTHER PHARMACOLOGICAL ROLES OF *Bacopa monnieri*:

- **Role in Kidney and Liver:**

Chronic administration of morphine has contributed to a significant rise in serum levels of the marker enzyme. Increased SGPT by 24 percent and SGOT by 40 percent after morphine administration [66]. Chronic administration of heroin has been reported toincrease ALT and LDH levels [67]. Increased serum marker enzyme operations may be due to the leakage of these enzymes. Liver enzymes as a result of cell damage. Sometimes, prescribing chronic morphine Serum-based urea, uric acid, and creatinine are caused by elevated levels. Increased quantities of those end-products of such products. Nitrogen metabolism can be due to the harm caused by morphine's long-term renal effects [68]. *Bacopa monnieri* pretreatment reduces the elevated levels of the marker enzyme to near normal, indicating the development of structural integrity of the hepatocyte cell membrane or the regeneration by *Bacopa monnieri* of damaged liver cells. This shows the efficacy of the extract in preserving the liver's normal function. There were no histopathological differences in bot rats pretreated with BME. The elevated level of enzyme marker concentrations is reduced to near normal by pretreatment with *Bacopa monnieri* and this means, The production of structural integrity of hepatocytes[69]. Cell membrane or regeneration of damaged liver cells in the case of *Bacopa monnieri*. This indicates the extract's effectiveness in maintaining proper liver function. In *Bacopa monnieri* pretreated rats, there were no histopathological variations in the bottlenecks. Morphine intoxicated rats received 10-160 mg/kg body weight of morphine hydrochloride for 21 days intraperitoneally. Pretreated Bacopa monniera extract rats were administered orally with *Bacopa monnieri* (40 mg/kg) once daily, 2 hours prior to injection of morphine for 21 days [70].

- **Role in CVS:**

The coronary artery is a significant cause of injury and death. Despite the widespread adoption of highly successful. Cardiovascular disease medications. The bulk of myocardial infarction cases (MI) [71]. It also results from the formation of an unstable atheroma. Fragments and clots that occlude downstream vessels. It culminates with regional myocardial ischemia. There are various cytopathological consequences of the resulting energy failure, including changes in pH and Na+ levels, resulting in the reversal of Na+/Ca2+ exchange, leading to cytosolic loading of Ca2+ and activation of proteolytic enzymes mediating necrosis [72]. Mytochondrial Ca2+ homeostasis also fails, leading to degradation of the electron transport chain, cytochrome C release, and initial apoptosis. Nonetheless, these ones, Adjustments are sluggish during prolonged occlusion, but damage begins with reperfusion Glucose shunning is the processing of lactic acid and mitochondrial glycolysis Oxidation by beta-fatty acid. Early reperfusion is accompanied by excessive superoxide production and thus contributes to the growth of other reactive species. Cell damage and more Ca2+ cytosolic loading[73]. We are, therefore, Ca2+, superoxide, superoxide, vasoconstriction and inflammation, both of which conspire, are a strong cytotoxic combination. For the next few minutes-the death of myocardial cells in an hour. The main findings of this study were that *B.monnieri* extract concentration was induced. Improvement based on coronary flow, facilitated cardiac function and decreased area of infarction in isolated perfused hearts due to ischemia and reperfusion [74]. Earlier, by inducing the release of endothelial NO, B. Monnieri was shown to dilate various isolated rat arteries. Inhibiting extracellular Ca2+ influx and release of Ca2+ from Reticulum sarcoplasmic, the smooth muscle vascular cells. B. Monnieri, thus providing the extra and intracellular environment with metabolic energy to restore it. At the same time, the action of the cardiac myocyte prevents its

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contraction before clearing the accumulated Ca2+, after which the sinus rhythm can be restored. In several studies, this Ca2+ overloading of cardiac myocytes has been highlighted and different drugs targeting this overload, including Ca2+ channel blockers, promote post-IR recovery. Hearts with either Krebs-Henseleit were perfused with (normal) solution, (controlled) or 30, 100 µg/ml B solution. Ethanolic extract monnieri (30 min), or (ii) with a regular solutionor extract for 10 min prior to ischemic no-perfusion (30 min) followed by reperfusion (30 min) with ischemic no-perfusion (30 min). The usual solution using Langendorff preparation. Infarct volumes were measured by staining with triphenyltetrazolium. Ca2+-currents of type L-type (ICa, L) the HL-1 cells, a mouse atrial cardiomyocyte cell line, were measured by whole-cell patching Cytotoxicity B. In rat ventricular myocytes isolated by trypan blue exclusion, monnieri was assessed.In hearts that are typically perfused, B. Monnieri improved coronary flow by 63 ± 13 percent (30 µg/ml) and 216 ± 21 percent (30 µg/ml) respectively. Compared to control (5 ± 3 percent), (100 µg/ml) (n = 8-10, $p < 0.001$) [75].

Several studies demonstrated that Calcium-induced contractions in the rabbit pulmonary artery and aorta were mitigated by the plant extract, indicating an inhibitory effect on the influx of Ca2+ into vascular smooth muscle cells. The plant extract mitigated calcium-induced contractions in the rabbit pulmonary artery and aorta, suggesting an inhibitory effect on the influx of Ca2+ into vascular smooth muscle cells [76]. The rats (50 mg/kg BW) were pentobarbital-anaesthetized. By intraperitoneal injection, and supplemented where possible. Fore-Fore-Fore—With Tape Adhesive, the limbs and hind limbs with the operating pad were fixed on the operating pad. The femoral triangle, formed by the femoral nerve, exposed to the femoral artery and femoral vein incision of the skin Retraction and receding. The femoral triangle, formed by the femoral nerve, is exposed to the femoral artery and femoral vein by skin incision. Retraction and receding.The femoral vein and artery is cannulated by them with Filled with a tube of polyethylene (PE50, 0.58 mm i.d. 0.96 mm o.d.). For experimental injections, heparinized (50 units/ml) saline. Drugs and the measurement of blood pressure [77].

Current research shows that Brahmi ethanol extract has a dose-dependent lowering of vasor and blood pressure, with laxative effects in rats. The decrease was temporary in blood pressure, and this was transient. Accelerated metabolism or redistribution may be a function of recovery. Construction of the active compounds of Brahmi. Aorta, basilar, and basilar vasodilator acts were generated by the extract. Mesenteric, lobar renal artery, femoral artery and tail artery. Effects of vasodilating agent Brahmi will lead to the fall in Peripheral resistance on resistance arteries and therefore the hypotension that is observed. This study was aimed at gaining some knowledge of the vasodilator [77].

- **Role in Breast Cancer:**

Breast cancer has become the second most common female cancer in the world and the fourth largest cancer in the world, a cause of cancer mortality [78]. Triple negative (MDA-MB-231), positive oestrogen receptor (T47D and MCF7) and positive human epidermal growth factor receptor 2 (HER2) The objective of the current study was to examine the results of combined doses of bac I and bac II therapy using four cell lines of representative subtypes of breast cancer (BT-474) [79]. The effects of high saponin concentrations of cell membrane permeabilisation lead to hemolysis cytotoxicity. And and However, anti-cancer properties, such as inhibition of proliferation, induction of apoptosis and attenuation of invasiveness, have been demonstrated at lower doses. In high-dose combinations which induced high-dose combinations, this anti-cancer activity of synergetic BAC I and bac II occurred. G2/M arrest and apoptosis, but also lower dosage combinations that did not cause apoptosis. This anti-cancer activity of bac I and bac II occurred in the high-dose combinations that induced high-dose combinations.Arrest and apoptosis of G2/M, but also lower combinations of dosages which did not induce apoptosis. In high-dose combinations that triggered high-dose combinations, this anti-cancer activity of bac I and bac II occurred. G2/M arrest and apoptosis, but also lower dosage combinations which have not induced apoptosis [80].

- **Role in Pancreas:**

Pancreatic lipase is one of the clinical targets for the treatment of obesity, since it is the most efficient lipid absorption enzyme [81]. Inhibiting pancreatic lipase activity can obstruct the breakdown of triglycerides and decrease fat absorption. Inhibition of pancreatic lipase function has been intensively studied to improve anti-obesity drugs [82]. The MeOH extract of B. monniera inhibited pancreatic lipase activity (IC50= 316.4 µg/mL). The soluble fractions of

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EtOAc and 1-BuOH, with IC50 values of 47.5 and 185.8 µg/mL, showed a greater inhibitory effect than their extracts. The components desrhamnosylacteoside (1) and plantainoside B (2) inhibited pancreatic lipase activity and their IC50 values were 33.0 and 32.5 µM, respectively. There was a weak inhibitory effect on Monnieraside IIII (inhibitionat 100 µM = 21.4 percent) (3) [83]. Active constituents 1, 2 and 3 contain caffeic acid in their chemical structures, and we have attempted to study some associated phenylpropanoids and other compounds to clarify the structural requirements for inhibitory effects [84]. In mice filled with olive oil, we investigated the effect of the main active ingredients 1 and 2 on plasma TG levels. Compounds 1 and 2 inhibited the plasma TG elevation at 2.0-, 4.0-, and 6.0 h. In conclusion, desrhamnosylisoacteoside (1) was isolated and confirmed to be the most active constituent, along with plantainoside (2). The definition of the group of catechols and the hydroxyl group of 1 position has been suggested. Furthermore, in mice loaded with olive oil, 1 and 2 demonstrated inhibitory effects on plasma TG levels[85].

- **Role in Chronic Pains:**

Medically, chronic pain is a lasting sense of pain that has biological, psychological and social expression and both nociceptive and neuropathic components at the same time. Chronic pain has cognitive, behavioural and emotional aspects that work together to exacerbate the associated pain and distress that results in physical disability [86,87]. More than 77 percent of people with chronic pain have a form of major depressive disorder (MDD) that can be identified and chronic pain is an important component of major depressive disorder [88]. In the acetic acid induced writhing test, BM aqueous extract (80 mg/kg, 120 mg/kg, 160 mg/kg orally) and methanolic extract (20 mg/kg and 40 mg/kg orally) were reported to exert their analgesic impact partially through the adrenergic mechanisms. This impact is clearly demonstrated by the presence of both 2 and 1 receptors, primarily in the spinal cord region [89]. BM has been reported to have a strong anti-inflammatory effect, apart from its strong analgesic effect, mediated in a dose-dependent manner by the dual inhibition of lipoxygenase (LOX) and cyclooxygenase 2 activity (COX-2). In order to investigate the potential role of bacopasides in direct COX-2 inhibition, our group used OE Docking software as previously described to dock aglycone part of Bacoside A3 (as a normal bacopaside) into the COX-2 active site [90]. BM has a strong protective impact against the harmful effects of opiates on major organs such as the brain, kidneys and heart. BM is well known for safe and well tolerated herbal therapy in multiple clinical trials, including various age groups [91].

Table No.3 In-Vivo study of *Bacopa monnieri*:

Model used and study design	Dose of BME	Effect of BME treatment	Reference
Ethylcholineaziridinium by ICV in male wistar rats	20,40 and 60 mg\kg BW	Reduced in reduction of cholinergic neurons and neurons density.	[92]
Scopolamine i.p in male Swiss albino mice	200mg\kg BW	Inhibit the AChE activity in cortex and hippocampus. Also elevate the expression of GluN2B	[93]
Trimethyltin(TMT) i.p. in male Swiss albino mice	50mg\kg BW	Reduction in spatial memory deficits and protect neurons	[94]
Colchicine ICV in male Wistar rats	50mg\kg BW	Reduced activity of SOD, CAT and GSH-Px	[95]

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Rotenone S.C. in rats		Reduced release of TNF-α and IL-6. Reduced level of α-synuclein.	[96]
Pilocarpine I.P in adult male Wistar rats	300mg\kg BW	After 15 days reduction in escape latency. Decrease in glutamate dehydrogenase and increase in NMDA R1 gene mRNA level	[97]
Pilocarpine I.P in adult male Wistar rats	300mg\kg BW	Increase in GAD activity. Inhibit reduction of GABA mediated inhibition.	[98]
Aluminium orally in male Wistar rats	40mg\kg BW	Reduced TBA-RS, 4-HNE and protein carbonyl content. Inhibit decrease in activity of SOD, GPx, GSH and GST	[99,100]
Streptozotocin ICV in male albino Wistar rats	30mg\kg BW	Increase in Na+, K+ and ATPase activity	[101]
Female Wistar rats	200mg\kg BW	Increase in level of dopamine, serotonin, acetylcholine and inhibit deposition of lipofuscin.	[102]

II. CONCLUSION:

Bacop amonnieri, a traditional Ayurvedic medicinal plant has intricate mixtures of chemical compounds, which exhibit various pharmacologically and biological activities. They have been used as traditional medicines and as memory-enhancing agents since ancient times. According to the long-established hypothesis, plant compounds can maintain the fundamental vitality in the body and have various neuroprotective mechanisms that empower them to be used as part of our well-being. This review reveals the effective use of *Bacopa monnieri* in cognition and neuroprotection and has a specific role in other organs that can be used in novel drug discovery.

CONFLICT OF INTEREST:

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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