Research Article **CODEN: IJRPJK** **ISSN: 2319 – 9563**

International Journal of Research in Pharmaceutical and Nano Sciences

Journal homepage: www.ijrpns.com

https://doi.org/10.36673/IJRPNS.2023.v12.i04.A16

AN UPDATED STUDY ON *BACOPA MONNIERI* L. 'BRAHMI': A REVIEW

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ABSTRACT

The material mentioned above leads one to the conclusion that *Bacopa monnieri* is a highly promising medicinal plant that has long been employed in Ayurveda. The chemistry and several functional characteristics of the herb *Bacopa monnieri* that are helpful to health are thoroughly examined in the current study of the literature. The plant was shown to have a variety of pharmacological characteristics. This plant may contain a variety of physiologically active substances, which could account for its pharmacological effect. Many studies are still needed to confirm its efficacy in treating different illnesses and determine how the extracts affect the final effect on gene expression.

KEYWORDS

Bacopa monnieri, Chemistry and Pharmacological properties.

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INTRODUCTION

Known by most as "Brahmi," *Bacopa monnieri L. (Family: Scrophulariaceae)* is a semi-succulent perennial herb that grows in marshy, humid and moist environments all across India. This is a long-used medical herb that has a fabled reputation for enhancing memory. It has been used for 5000 years in India to treat anxiety and herbal sedative, as well as epilepsy and insomnia[1,2]. Indian Materia Medica suggests using this plant to treat a variety of mental health issues, such as anxiety, depression, psychosis, epilepsy, anxiety, poor memory, loss of focus, sleeplessness, insanity and Alzheimer's disease. Clinical research confirms that formulations based on bacopa have a beneficial impact on the

restoration of mental functions in children with attention deficit hyperactivity disorder [ADHD] and also help stroke and epilepsy patients perform better cognitively[3,4]. Compounds linked to the aforementioned activities include triterpenoids and bacosides, which are members of the saponin family. *Monnieri Bacupa Linn*. Called "Brahmi" in Hindi and "water hyssop" in English, this perennial herb belongs to the Schrophulariaceae family and is creeping. It has small leaves and white or purple blooms. It grows in warm wetlands and is native to Australia and India. It is also discovered growing in East Asia and the United States. In Ayurveda, it has been utilised as a medicinal herb for ages. It is used to treat tumours, ulcers, asthma, and epilepsy. It was first mentioned in writings like the Charaka Samhita, the Atharva-veda and the Susurtu Samhita around the sixth century A.D. Bacopa monnieri is a member of the class of medications known as medhya rasayana, which has been used in many constitutions to improve memory and promote mental wellness. When it comes to developing drugs, natural ingredients have proven invaluable as a biologically validated rostrum. For thousands of years, natural products have been utilised to treat a variety of illnesses. Approximately 80% of the world's population, according to the World Health Organisation [WHO] [WHO fact sheet, 2003], receives at least some of their primary healthcare from traditional medicines. Numerous active ingredients found in many herbs contribute to the plant's medicinal usefulness. Certain chemicals found in plants have a unique physiological effect on humans, which gives them their medicinal significance. Alkaloids, flavonoids, tannins, and phenolic compounds are the most significant of these bioactive plant components. This review aims to clarify the therapeutic application of *Bacopa monnieri* by examining its impact on various qualities and focusing on neuro-pharmacological mechanisms that reveal the herb's nootropic effect[5,6].

Taxonomic Classification

Kingdom: Plantae
Division: Tracheophyta
Class: Magnoliopsida
Order: Lamiales
Family: Schrophulariaceae
Genus: Bacopa
Species: monnieri [L.]

Description of the herb

Bacopa monnieri, sometimes known as BM, is a tiny, somewhat fleshy herb that creeps. The 10-30cm tall leaf- and flower-bearing stems originate from creeping stems that take root at the nodes. Therefore, bacopa's growing behaviour is similar to peppermint's. Simple, opposite, obovate-oblong leaves measure about 2cm by 1cm and have complete margins. Blue or white blooms with purple veins are borne singly on long pedicels in the leaf axils. The corolla has five lobed petals and is either pink or white with purple specks. The fruit, which is a capsule up to 5mm in size, forms in the persistent calyx [Figure No.1]. Bacopa belongs to the Scrophulariacea family[7,8]. The herb *Bacopa monnieri* is non-aromatic. This plant has oblong, succulent leaves that are 4-6mm [0.16-0.24 in] thick. Oblanceolate leaves are borne opposite each other on the stalk. The tiny, actinomorphic, white flowers have four to five petals. Even mildly brackish conditions will support its growth. Often, cuttings are used for propagation. Among the most common Bacopa species is *Bacopa monnieri*. Across India, Nepal, Sri Lanka, China, Pakistan, Taiwan, Vietnam, tropical and southern Africa, Madagascar, Australia, the Caribbean, Middle and South America and Madagascar, it is typically found growing in marshy places. Additionally, Florida, Louisiana, Texas and Hawaii are home to it[9,10].

History and Development

Based on factors such as medicinal relevance, potential as a candidate, and economic worth, *Bacopa Monnieri* has been ranked second among the important Indian medicinal plants in terms of priority for research and development. It has a

wide range of pharmacological properties, such as adaptogenic, anti-ulcerogenic, anti-depressant, anxiolytic, anti-neoplastic and anti-conversant properties. This herb can remove excess harmful metals from the bloodstream by acting as a mental chelating agent. In phytoremediation, it is also utilised to remove heavy metals including cadmium and chromium[11,12]. Pharmacologists and herbal traders gather *Bacopa monnieri*, the only herbal source of bacosides, at a very high rate from its natural habitat. Because of its enormous variety of medicinal uses, researchers have focused on mass plant propagation as well as alternative approaches for biotechnologically producing its active principles, the *Bacopa saponins*. This has resulted in a significant amount of literature on the species' *in vitro* propagation. By avoiding the impacts of exogenous phytohormones, the morphogenic potential of *Bacopa* monnieri explants favours their use as a model plant for *in vitro* research on the expression of transgenes on organogenesis in vitro and functional studies on bacoside production *in vitro*[13,14].

Findings

Bacopa's value in medicine and pharmacology is growing every day. *Bacopa Monnieri* exhibits enormous promise in treating a wide range of neuropharmacological, inflammatory, depressive, and other conditions. However, extensive research is needed in the future to confirm its effectiveness for a range of illnesses. At different quantities, the ethanolic and methanolic extract of bacopa is essential for treating human ailments. The broad chemical agent that has been linked to the therapeutic effects seen in a number of research models is called bacoside A. However, more research is needed to ascertain the specific function of the bioactive substances found in the separated bacoside fraction of *Bacopa Monnieri*[15,16]. Further research is necessary to determine whether bacopa's antioxidant activity may be used to treat human illnesses where free radical generation is a significant factor. Although bacopa biomedical research is still in its infancy, early findings like as those presented in this review can undoubtedly provide budding researchers with a wealth of opportunities[17].

Synonyms

Bacopa, brambhi, thyme-leaved Gratiola B.S: It consist of fresh leaves and stem of the plant known as *Bacopa moniera Linn*.

Family

Scrophulariaceae [NLT 2.5% of bacoside A on dried bases].

Geographical Source

It is a prostrate, succulant herb found in India, in wet, damp and marshy places, upto 1200m elevation.

Cultivation and Collection

Succulent and water loving plant

Grow under varying soil and climate condition.

Grow faster in 30-40°C and humidity 65- 80%, cultivated as summer rainy season.

Planted in march-june allowed to grow and proliferate through hot and humid months of monsoon till September after which harvest should be taken. [inS.Ind. It can be grow throughout year]

Before planting, field should be ploughing, make free from weeds, moistened the soil.

Before removing from nursary, nursary should be flooded. Taking care in cutting and dugging. Cuttings about 6-8cm long, containing nodes with root used for transplanting

1 day before planting, vermicompost is spread on the surface of the plots and mixed throughlywith top 10cm soil and then flooded.

Cutting saw in wet soil at a 15 * 15cm distance.

Flood irrigation should be provoded

Harvest management

Crop maturity and harvesting

After sowing, the crop can be harvested 75-90 days later. The finest months to harvest are September and October. When the crop reaches a length of 20-30cm, it should be harvested[18,19].

Post harvesting management

To dry the produce, spread it out on a clean surface and bake it in the sun for four to five days, then let it dry in the shade for the next

seven to ten days. The clean container is where the dried stuff should be stored. After six months of storage, the content starts to decrease.

Yield and cost of cultivation

After drying, a pure crop's fresh yield of 22.5 tonnes per hectare drops to about 5.5 tonnes per hectare. Bucopa is projected to produce 3.75 tonnes of dry matter per hectare when grown as an intercrop with peddydry matter[20,21].

Morphology

Colour: Green

Taste: Bitter

Size: Leaves are about 2cm.

Shape: Leaves: flachy, obovate, alternate, simple, entire, with broad apex, sessile and lower surface is dotted.

Flower: Solitary, stalked, corola bluish white in colour and about 1cm in size. 1 of the 5 sepelsis larger then others. Arise in axes of the leaves in April-June. Capsule are Ovoid.

Seed: minute and numerious

Bacopa is a succulent, glabrous, creeping herb, with rooting at nodes. The plant is easily recognized by its spreading habit, sessile and fleshy leaves, and light bluish, purple or white flowers. Leaves are ovate and opposite with dotted lower surface.

Parts used: Whole plant

***Bacopa monnieri* stem**

[a] Vascular bundle and big pith in the centre; [b] Y-linked parenchyma cells; [c] Calcium oxalate prismatic crystal; [d] Xylem phloem. Well-known herbal medicine brahmi has been shown to improve memory by acting on the brain. *Monnieri Bacopa*[22,23].

Macroscopic

The plant is formed of crumpled, matted broken parts of roots, branching stems, leaves, flowers, and a few fragile fruits. It has a somewhat bitter flavour while fresh and has no distinct odour when dried.

Root

Fragments of dried main roots are cylindrical, about 5mm in diameter, longitudinally wrinkled andoff-white in color[24].

Stem

Pieces of the stem are cylindrical, glabrous, nodes prominent, at places attached with vertically growing branches and ventrally to cluster of tortuous, brittle roots, internodes about 1-1.5cm in length and 3-4mm in diameter, pale yellowish green and with purplish ting[25,26].

Leaf

Simple, opposite and decussate, somewhat sessile, glabrous, obovateoblong to spatulate in shape, 0.6-2.5cm in length and 3-8mm in width, entire, lower surface dotted with minute specks, obscurely1-3 nerved, color faint green[27].

Flower

Pale blue or pinkish white, nearly regular, solitary, axillary. 0.6-3cm in length, usually longer than the leaves with two linear bracteoles, pedicel slender, calyx glabrous, deeply 5 partite Corolla gamopetalous, stamens 4, didynamous, anthers 2 celled, pistil carpel, syncarpous ovary two chambered with many ovules, style dilated toward the top, stigma-bilobed[28,29].

Fruit

Globose to ovoid, glabrous capsule, 5mm in length, enclosed within persistent calyx, ped 1-3cm long purplish when fresh[30,31].

Seed

Numerous, very minute, <1cm wide, oblong or irregular.

Microscopic

Root

The root exhibits an irregular circular to angular shape, with an outermost piliferous layer, a parenchymatous cortex with air spaces between it and the xylem, and a solid core of xylem surrounded by narrow phloem located in the centre. The formation of cork cells replaces the piliferous layer; the cortex is broad and parenchymatous, with simple and compound starch grains passing through it and air spaces in between; the endodermis is a distinct layer of phloem that surrounds the solid core of xylem, which is made up of medullary rays, isolated vessels arranged radially and fibres.

Stem

With a layer of thick-walled celled epidermis covered in thin cuticle, the stem's outline is almost circular and features an outer epidermis, a broad aerenchymatous cortex that occupies the majority of the section, a distinct endodermis surrounding the ring of stellar tissue and a central parenchymatous pith. The cortex is very wide, consisting of chlorenchymatous aerenchyma embedded with starch grains, the endodermis is distinct, encircling the narrow band of parenchymatous phloem and xylem and the central region is occupied by narrow parenchymatous pith that features simple and compound starch grains[32].

Leaf

The leaf that passes through the midrib has an extremely thin elevation on the top side of the midrib and an almost cylindrical form. Both the top and lower epidermis have sessile-glandsular trichomes with multicellular heads and the cells of the upper epidermis are larger and occasionally exhibit striated cuticle. The epidermis is embedded with stomata.

Beneath the midrib's epidermis is a short collenchymatous band that displays a conjoint collateral meristele centred and surrounded by a parenchymatous sheath. The spongy parenchyma that makes up the mesophyll tissue of the lamina is crisscrossed by vascular strands; contained in the parenchymatous cells of the leaf are prismatic and a few cluster crystals of calcium oxalate.

Powder

Displays surface view fragments of the upper and lower leaf epidermis embedded with sessile-glandsular trichomes with 4-8 celled heads and diacytic to anomocytic stomata, which are more numerous on the lower side, with sinuous anticlinical walls and striated cuticle at times; prismatic, cluster crystals of calcium oxalate, starch grains and oil globules scattered as such throughout or embedded in the parenchymatous cells; fragments of longitudinally cut annular and spiral vessels; transversely cut stem segments displaying aerenchymatous cortical cells, papillose marginal cells of the petal, surface view testa of the seed and transversely cut fragments of cotyledon.

Chemical constituentsMajor

Bacoside A

Alkaloids, saponins, herpestine, and brahmine are the main ingredients. The saponins known as betulic acid, bacoside A and bacoside B.

Isolated compounds include D-mannitol, stigmastanol, β-sitosterol and stigma sterol. Bacoside A hydrolyzed in acid to yield three sugars, two of which were recognised as glucose and arabinose. Bacoside B likewise hydrolyzed to yield glucose and arabinose[33].

Others

Bacoside B, bacoside A1, bacoside A3, bacogenin A1, bacogenin A2, bacogenin A3, bacogenin A4, bacopa saponin-C,

Bacopasides I and II, bacopasides III-V, bacopasides VI-VIII, bacobitacins A-D, monnieraside I, monnieraside III, monnieri, plantioside B; jujubogenin, pseudojujubogenin, 3-O-β-D- glucopyranosyl-[l—»3]-[β-Dglucopyranosyl] jujubogenin,

3-O-[β-D—glucopyranosyl-[l—»3]-[β-Dglucopyranosyl] pseudojujubogenin, betulinic acid,wogonin, oroxidin, luteolin,

Luteolin-7-glucoside, luteolin-7-glucuronide, apigenin7-glucuronide; nicotine, 3-formyl-4-hydroxy-2H-pyran, bacosine, bacostcrol,

Bacosterol-3-O-β-D-glucopyranoside,

stigmasterol, stigmastanol, β-sitosterol, D-mannitol,and an uncharacterized glycosidase.

Chemical test of *Bucopa monnieri*

Wagner's reagent [Iodine-potassium Iodide solution solution]

A solution of 1.3g iodine and 2g of potassium iodide in 100ml of water. It gives reddish brown ppt. with most of the alkaloids even the purine bases.

Dragendorff's reagent [potassium bismuth Iodide]. Bismuth nitrate, nitric acid, pot. Iodide and water. It givesan orange ppt.

Mayer's reagent [potassium mercuric iodide]. HgCl2 [1.36g] + KI [Sg] + H2O [100mI]

It gives white ppt. It is the most generally used of the alkaloidal reagents. The solution should be added to distinctly acidic solution of the alkaloid, only few drops of the reagent should be used and the solution should not contain acetic acid or alcohol.

Tests for carbohydrate [Molisch's test]

A few drops of Molischs solution was added to 2mL of aqueous solution of the extract, thereafter a small volume of concentrated sulphuric acid was allowed to run down the side of the test tube to form a layer without shaking. The interface was observed for a purple colour as indicative of positive for carbohydrates.

Test for saponins [Frothing Test]

Three millilitres [3mL] of the aqueous solution of the extract were mixed with 10mL of distilled water in a test-tube. The test-tube was stoppered and shaken vigorously for about 5 min, it was allowed to stand for 30 min and observed for honeycomb froth, which was indicative of the presenceof saponins.

Pharmacological activities

Memory enhancer
Antidepressant
Anxiolytic
Antiperkinsonism
Anticonvulsive
Antioxidant
Anti-inflammatory and analgesic
Gastrointestinal effect
Antimicrobial effect
Antiepileptic
Endocrine effect
Morphine withdraw effect
Immunostimulator
Hepatoprotective
Nootropic
Epilepsy
Antipyretic
Diuretic
Antirheumatic
Renoprotective effect
Anticatdiovascular
Anticancer
Antihyperglycemic

Central nervous effects

Memory enhancement

Animal behavioural research has demonstrated that Bacopa enhances motor learning, as well as the acquisition and retention of novel behaviours, delaying their eventual extinction.

Using the forced swimming test (FST) and tail suspension test (TST) on mice, the antidepressant efficacy of B. monniera methanol extract and various fractions was assessed. The findings demonstrated that, following oral administration for five days in a row, the methanol extract, ethanol and butanol fraction dramatically shortened the immobility durations in both the FST and TST in mice. Every sample that was evaluated did not have any inhibitory effect against locomotor activity [LA] in effect at the effective dosages of FST and TST[34].

However, it was shown that bacosides improve the level of acetylcholine and the hypoxic environment, which may help anterograde memory and reduce anterograde experimental amnesia caused by scopolamine and sodium nitrite, respectively. Furthermore, bacosides prevented retrograde amnesia caused by BN52021, a platelet-activating factor receptor antagonist. This was most likely caused by an increase in platelet activating factor production through improved cerebral glutamate levomemory. When bacopa was used, memory problems caused by scopolamine-induced cholinergic blockade were alleviated. In cohorts that were cognitively intact, bacopa enhanced memory functioning, while pycnogenol enhanced working memory. Benzodiazepines are known to cause amnesia through interfering with long-term potentiation and involving the GABAergic system. The behavioural study demonstrated that the amnememor caused by diazepam was greatly reversed by *bacopa monniera*. Phenytoin-induced cognitive impairment was dramatically reversed by bacopa administration, as evidenced by better memory acquisition and retention. A 12-week clinical research was conducted to evaluate the

impact of 300mg/day of *Bacopa monnieri* on memory function in adults over the age of 55. In elderly people, bacopa dramatically enhanced memory acquisition and retention. Chronic administration of Bacopa extracts has been shown to have significant cognitive-enhancing effects. The same patient selection criteria and the same dose of Bacopa extract (300mg daily) containing 55% combinedbacosides were used in a double-blind, placebo-controlled, 12-week experiment. 46 healthy volunteers, ranging in age from 18 to 60, were split equally and at random into groups receiving a treatment and a placebo. At baseline, five and twelve weeks after the start of treatment, the identical set of tests as were conducted in the acute dose trial were given. Results showed that the treatment group significantly outperformed the placebo group in verbal learning, memory consolidation and early information processing speed at the conclusion of the 12-week trial.

Antidepressant

When evaluated on forced swimming and tail-suspension models in experimental animals P[23-25]P, bacopasides A and B, bacopasides I and II, bacopasaponin C and the extract of *Bacopa monniera* showed antidepressant action. Bacopaside VII did not show any antidepressant activity.

Anxiolytic

Bacopa monnieri's crude plant extract, commonly known as bacosides, has also demonstrated antioxidant, antidepressant, and anxiolytic properties[25]. As an adaptogen, *bacopa monnieri* proved very successful in restoring rats' corticosterone levels after both acute and chronic stress. Moreover, it restored noradrenalin [NA], 5-HT and DA to normal in the rat brain and hippocampal regions during both acute and long-term unexpected stress[26]. Bacopa has antioxidant and metal-chelating properties in addition to modulating the cholinergic system. Bacopa was found to reverse the cognitive deficits caused by the neurotoxins colchicine and ibotenic acid in an animal model in a dose-dependent manner[27,28]. *Bacopa monniera* increased 5-hydroxytryptamine levels in the cerebral cortex, hypothalamus and hippocampal regions while decreasing norepinephrine levels. Comparing the higher doses of Bacopa monniera extracts to lorazepam, a common anxiolytic medication from the benzodiazepine group P[30]P, revealed noticeably more anxiolytic effects. Nevertheless, the whole brain turnover of mice treated with *Bacopa monnieri* methanolic extract (10, 20, or 30mg/kg) for one week did not alter dopamine (DA) or serotonin (5-HT)[30].

Antiparkinson

Bacopa monnieri has demonstrated potential as an anti-Parkinsonian drug by reducing alpha synuclein aggregation, preventing dopaminergic neurodegeneration and restoring the lipid content in nematodes in pharmacological Caenorhabditis elegans models of Parkinson's disease.

Anticonvulsant

Bacosides or crude plant extract of *Bacopa monnieri* have also demonstrated anticonvulsive properties[26]. It had neuroprotective properties against glutamate-mediated excitotoxicity during seizures and against cognitive impairment linked to epilepsy brought on by pilocarpine[33]. Using a variety of convulsive models, including strychnine and maximal electroshock-induced convulsions in rats, hypoxic stress-induced convulsions in mice, and lithium-pilocarpine-induced status epilepticus, the anticonvulsant activity of the ethanolic extract of *Bacopa monniera* was evaluated. For rats and mice, the ethanolic extract of *Bacopa monniera* was given orally at 50 and 55mg/kg, respectively, two and four hours before to the corresponding convulsive stimuli. For every model examined, the ethanolic leaf extract demonstrated strong anticonvulsant effect with a mechanism of action like that of benzodiazepines [GABA agonist][35].

Antioxidant

Using the Folin ciocalteau method, the total phenolic content of the *Bacopa monniera* aqueous extract was reported to be 58mg gallic acid equivalent/g. In contrast, the hydrogen

peroxide scavenging approach yielded an IC50 value of 254.70µg/ml[35]. In adult male Sprague Dawley rats, the antistress effects of bacosides of Brahmi [*Bacopa monnieri*] were investigated by oral dosages of 20 and 40mg/kg for seven days in a row. Whereas stress by itself significantly increased the expression of Hsp70 in every analysed brain region, baclosides, at both doses, did not significantly alter Hsp70 expression in any of the studied brain regions. Superoxide dismutase [SOD] activity was shown to be significantly lower in the hippocampus with the lower dose of bacosides, but it was found to be higher in the brain areas with the higher dose. Following exposure to stress alone and with both doses of bacosides, there was an increase in the activity of cytochrome P450-dependent 7-pentoxyresorufin-o-dealkylase [PROD] and 7-ethoxyresorufin-o-deethylase [EROD] in all brain regions; however, the degree of induction of P450 expression was lower with a higher dose of bacosides. It's interesting to note that stress reduced Hsp70 expression in all areas of the brain in the rats given bacosides for seven days, with the hippocampus showing the greatest reduction. Similarly, it was discovered that in all brain regions of the rats given a lower dosage of bacosides and then stressed, the activity of SOD was further decreased. On the other hand, animals treated with a higher dose of bacosides and then exposed to stress showed marked increases in enzyme activity in the cerebral cortex and other regions of the brain, while the hippocampus and cerebellum showed much smaller reductions in SOD activity. Similarly, P450 enzyme activity was found to return to nearly control levels in animals exposed to stress and pretreated with the higher dose of bacosides. In contrast, animals pretreated with the lower dose of bacosides and exposed to stress showed less induction of P450 enzyme activity than animals treated with bacosides or stress alone. According to these findings, bacosides may be able to alter the activities of Hsp70, P450, and SOD, enabling the brain to become ready to respond in stressful situations[34]. Rats treated with alcoholic extract of *Bacopa monniera* were protected against morphine-induced reduction in GSH levels and inhibition of antioxidant enzymes[36].

Anti-inflammatory and analgesic effects

At anti-inflammatory concentrations, *bacopa monniera* did not produce stomach discomfort and successfully inhibited the experimentally created inflammatory reaction effect by decreasing prostaglandins generation and partially stabilising lyosomal membranes. At oral doses of 250 and 500mg/kg [P<0.001], the ethanol extract of the entire *Bacopa monnieri* plant significantly reduced writhing in mice elicited by acetic acid, in a manner similar to that of diclofenac sodium 25mg/kg. The several Bacopa monnieri extracts' anti-inflammatory properties were studied in rat hindpaw edoema caused by carrageenan. The edoema paw volume was significantly reduced by the methanol extract and aqueous fractions [100mg/kg], however the hexane and petroleum ether extracts did not lessen inflammation[37]. Utilising the membrane stabilisation technique of human red blood cells [HRBC], the *in vitro* anti-inflammatory effect of *Bacopa monnieri* was evaluated. Diclofenac sodium was not as effective in producing membrane stabilisation as methanolic extract and the callus [100, 200, 300µg][38]. The triterpenoid and bacoside found in *Bacopa monnieri* are responsible for the plant's anti-inflammatory properties. By regulating the release of pro-inflammatory mediators, *Bacopa monniera* can reduce inflammation.

Gastrointestinal effects

When castor oil was used to produce diarrhoea in mice, the entire *Bacopa monnieri* plant was extracted using ethanol and shown antidiarrheal properties. At an oral dosage of 500mg/kg, which is equivalent to 50mg/kg of loperamide, it considerably reduced the frequency of defecation and lengthened the mean latent duration. Juice from fresh Bacopa monniera shown strong antiulcerogenic properties. For stomach ulcers,

bacopa has both a preventative and therapeutic impact. The preventive and therapeutic effects of the Bacopa extract standardised for bacoside-A in rats were assessed using five different models of stomach ulcers. Bacopa extract effectively improved the mucosal barrier, reduced mucosal exfoliation, and repaired penetrating wounds caused by acetic acid when administered at a dose of 20mg/kg for 10 days. The rat stomach mucosa's lipid peroxidation was significantly reduced, indicating that the extract also reduced stress-induced ulcers. Additionally, it had an anti-H. pylori action. The effects of an Ayurvedic concoction including *Bacopa monniera* and Aegle marmelos were compared with standard medication [clidinium bromide, chlordiazepoxide and psyllium] in a double-blind, randomised, placebo-controlled experiment involving 169 individuals with irritable bowel syndrome. For six weeks, the subjects were randomised to receive either a placebo, a normal medication treatment, or a botanical treatment. Three times a day, the treatment was given orally as a medication, herb, or placebo. Although Ayurvedic treatment was better than a placebo, the two botanicals were not administered individually and the advantage could not be directly attributed to the Ayurvedic preparation's bacopa component.

Antimicrobial effects

When compared to other extracts, methanol extracts were discovered to be the most effective antibacterial agent. No action was seen by aqueous extracts against any of the bacteria. In contrast to methanol extracts, hexane and petroleum ether extracts exhibited comparable antibacterial activity, but less significantly. The methanol extracts were reported to have the lowest minimum inhibitory concentration (MIC) against *Salmonella typhimurium, E.coli, Staphylococcus aureus and Saccharomyces cerevisae*[37]. Maximum activity was seen against *Staphylococcus aureus* and good activity was observed against *Salmonella typhi, E.coli* and *Staphylococcus aureus* in a methanolic extract of *Bacopa monnieri callus* (1mg/ml). There was no evidence of K. pneumoniae activity[38]. Ether extract of *Bacopa monnieri* showed antimicrobial activity against four bacteria and one fungus, *Salmonella typhi, Pseudomonas aeruginos, Staphylococcus aureus, Vibrio cholera* and *Candida albicans*.

Endocrine effects

Mice treated with 200mg/kg of bacopa extract had a 41% increase in thyroid hormone (T4). Since T3 was not stimulated, it is possible that the extract directly stimulates T4 synthesis and/or release at the glandular level without influencing T4 to T3 conversion. Fertility and spermatogenesis were reversibly suppressed by bacopamonniera extracts. The medication changed the somniferous tubules in mice, decreased sperm motility and viability, and decreased the amount of spermatozoa in the caudaepididymidis and testis[37].

Other effects

In an isolated rabbit heart, the ethanolic extract of the entire *Bacopa monnieri* plant shown cardiac depressing activity on left ventricular contractility, heart rate and coronary flow. It seemed that the extract's heart-related effects were comparable to those of quinidine[53]. In experimental animals, bacopa has relaxing effects on the smooth muscles of the aorta, trachea, ileum and bronchi.

Antiepileptic

The plant's crude aqueous and defatted alcoholic extracts were used in a clinical research including 24 patients with a range of mental disorders. The study found that epileptic patients treated with defatted alcoholic extract [2-4mg/kg b.w.] and crude aqueous extract of "brahmi" twice daily for five months showed improvements in their learning processes and corrections in their abnormal behaviour. It was discovered that the defatted alcoholic extract of "brahmi" was more effective at relieving epileptic fits than the watery form. In order to substantiate the sedative and tranquillizing qualities of crude BMEs (four patients), Marsilea minuta (two patients) and

Acorus calamus (six patients), a controlled clinical trial was conducted in epileptic patients, with particular reference to changes in Electro Encephalo Graphy (EEG). One case of each of petit mal epilepsy and temporal lobe epilepsy showed improvement after using the defatted alcoholic extract of "brahmi." In these two patients, there was a strong correlation between the EEG alterations and the clinical improvement.

Endocrine effects

In mice, oral BME (200mg/kg) boosted the thyroid hormone (T4) by 41%. Since T3 was not stimulated, it is possible that the extract directly stimulates T4 synthesis and/or release at the glandular level without influencing T4 to T3 conversion. Reversible inhibition of fertility and spermatogenesis was brought about by BMEs. The sperms' motility and viability decreased as a result of the treatment. It changed the somniferous tubules in mice, as well as decreased the amount of spermatozoa in the cauda epididymis and testis.

Morphine withdrawal effects

In vitro testing was done to determine how the alcoholic extract of the entire BM [Scrophulariaceae] plant affected morphine withdrawal. In ileum of guinea pigs. Following a 4-minute in vitro morphine exposure, naloxone was added to cause a forceful contraction, and then different doses of the alcoholic BM extract (100-1000µg/ml) were added. In a dose-dependent way, the naloxone-induced contraction was lessened 15 minutes prior to exposure to morphine. The findings imply that BM extract can be helpful in lessening morphine-induced withdrawal symptoms.

Hair growth promoting activity

Herbal hair oil made from the alcohol extract of Cyperus Rotundus, BM, and Emblica officinalis, either together or separately. Using coconut oil as the base, the three herbs were made separately, in varied concentrations and as a mixture in a predetermined proportion for the hair oil. By applying the prepared oil topically to albino rats' shaved skin, its physical, chemical, and hair growth capabilities were assessed at different concentrations. Using healthy albino rats, the primary skin irritation test, the hair length test, and the hair growth were compared with a standard minoxidil 2% ethanolic solution. It was observed that hair oil formulation showed the best result among the other formulation evaluated by showing an enlargement of Follicular size and prolongation of the anagen phase.

Bacterial effect

BM's antibacterial efficacy was tested against several bacterial strains using petroleum ether, methanol, ethanol and chloroform. To identify the chemicals causing these actions, a phytochemical screening was done. Chloroform, ethanol and methanol Bacillus amyloliquefaciens [MTCC 1270], Streptococcus pyogens [MTCC 1923], Bacillus pumilus, Salmonella Typhi, Bacillus subtilis, Bacillus megaterium [MTCC 3353], Aspergillus niger [MTCC 281] and Micrococcus luteus were the pathogens against which the extracts were tested. The Bacteria's susceptibility to the crude extracts based on growth inhibition zones varied depending on the extracting solvent and the microorganism. The maximum activity was obtained by the methanol extract in the majority of the plants indicated above. Based on the results, it is possible to draw the conclusion that antimicrobial chemicals from leaves can be extracted using methanol.

Anti-cardiovascular activity

Children

Children 6 to 12 years old may safely take bacopa orally for up to 6 months. Bacopa may be used to treat brady cardia, or a slow heart rate. For those who already have a sluggish heartbeat or another heart condition, this can be an issue.

The blood-brain barrier (BBB) can be crossed by the bacosides found in bacopa, and their bioavailability in the brain-including the activation of a cascade that plays a role in memory enhancement-has been demonstrated.

Anti-cancer Activity

One of the leading causes of death in the world today is cancer. Natural product-based cancer prevention is widely accepted these days. Natural substances called phytosterols have anticancer properties in addition to other properties. Swiss albino mice treated with ehrlich ascites carcinoma (EAC) were found to be resistant to the phytosterol stigmasterol, which was extracted from the aerial portions of *Bacopa monnieri*. Stigmasterol extended mean survival time, reduced tumour volume, packed cell volume, and viable cell count, all of which extended the life duration of EAC tumor-bearing mice. It is possible that the activation of protein phosphatase 2A by ceramide, which results in apoptosis, is how stigmasterol's anticancer effect is mediated. *Bacopa monnieri's* ethanolic and dichloromethane [DCM] extract has been shown to have cytotoxic effects on the MCF-7 and MDA-MB 231 cell lines. Cytotoxic activity in DCM fraction in both the cell lines may be due to the presence of cucurbitacins and betulinic acid in DCM fraction.

Anti-hyperglycemic Activity

The plant's methanolic extract has strong anti-hyperglycemic properties. The extract, given at four doses of 50, 100, 200 and 400mg per kg body weight, dose-dependently and significantly inhibited the increase in serum glucose concentrations by 33.3, 34.2, 42.1 and 44.2% 47 in OGTT [Oral glucose tolerance tests] with glucose-challenged mice.

In streptozotocin-induced diabetic rats, *Bacopa monnieri* was shown to have anti-diabetic properties. After receiving Brahmi treatment (500mg/kg b.w.), the elevated blood glucose and glycated haemoglobin levels in diabetic rats were normalised. In contrast, the reduced levels of haemoglobin, total white blood cell count, and platelet count were comparable to those of the rats treated with glibenclamide (600µg/kg b.w./day) 48. This study demonstrates that in streptozotocin-induced diabetic rats, Bacopa monnieri exhibits strong antihyperglycemic effects. In normal rats, BM-1, an active chemical isolated from Bacopa monnieri leaves, significantly lowers blood cholesterol, triglycerides, LDL and VLDL. Additionally, BM-1 reduced elevated levels of triglycerides, LDL, VLDL, and serum cholesterol in diabetic rats, while increasing HDL cholesterol. *Bacopa monnieri* extract may be used to treat hyperlipidemia in diabetics, according to these studies[38,39].

Figure No.1: *Bacopa monnieri* plant

Figure No.2: Root

Figure No.3: Stem

Figure No.4: Leaf

Figure No.5: Flower

CONCLUSION

The tissue culture methods created for this plant's growth can be applied to preserve the germplasm of this significant medicinal plant, which will speed up multiplication and cut down on manufacturing time and expense. The discovered transformation procedure can be applied to genetically modify *Bacopa monnieri* to improve its medicinally significant metabolites. Furthermore, an effective substitute for boosting metabolite production is the strategy designed to improve the synthesis of secondary metabolites. Therefore, there's still a lot of room in this industry to make greater use of this amazing plant.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to Buddha Institute of Pharmacy, GIDA, Gorakhpur, Uttar Pradesh, India for providing necessary facilities to carry out this review work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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Please cite this article in press as: Ravindra Singh *et al*. An updated study on *Bacopa monnieri* l. 'Brahmi': A review, *International Journal of Research in Pharmaceutical and Nano Sciences,* 12(4), 2023, 130-144.