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Review Article

BRAHMI (*BACOPA MONNIERI*)- A POTENTIAL AYURVEDIC COGNITIVE ENHANCER AND NEUROPROTECTIVE HERB

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ABSTRACT

In Ayurveda, a wide variety of neuroprotective herbal plants have been reported. *Brahmi*, *Bacopa monnieri,* belonging to the family *Scrophulariaceae,* is one of the foremost nootropic and neuroprotective Ayurvedic herb known from ancient times. It is used in the traditional medicinal system to treat various brain related health problems and as a memory enhancer. In the modern era, it is generally used to upgrade memory, learning and to treat tension, depression and other major problems like cardiovascular diseases, gastrointestinal, hepatic, neurological and respiratory problems. There were vast reported studies on the Alzheimer's disease also, *Brahmi* is known to have anticancer, antidiabetic, mitigating, antimicrobial and antioxidant properties. Bacopa plants contain various phytochemicals which include alkaloids, flavonoids, glycosides and saponins. Other important constituents present in this plant are bacosides, bacopasides, and bacopa saponins, which are responsible for its therapeutic properties.

KEYWORDS: *Brahmi*, *Bacopa monnieri, Rasapanchak*, Bacopasides, Glycosides, Antidiabetic, Anti-oxidant.

INTRODUCTION

Plants are the main source of drugs and play a vital role in the world healthcare system.[1] The plants and their extracts are used in different cultures worldwide. The repeated use of the herbal plants proves that these plants contain significant therapeutic properties which are helpful to treat human and animals.[2] From ancient times, plants are considered a rich source of imperative and secure medicines. Herbal medicines have been considered as a primary source of the essential medical system around the world. About 80% of the world population rely on traditional medicines.[3] Indian Vedas depict the considerable use of classical herbal drugs to treat various diseases. Approximately, 30% of the root part of the plant is used in different practices as compared to other parts of the plant.[4] As per resources, 80% of modern medicines are directly or indirectly prepared from plant extract.[5] Ayurveda or the Indian System of Medicine viz. *Sushruta Samhita, Charak Samhita* and *Atharva Veda* describe plants which have a *Prabhava* (specific action) on the intellect and memory as *Medhya Rasayana* (*Medhya*– intellect or retention, *Rasayana*– procedure or preparation). In India, *Bacopa monnieri* L. Penn. and *Herpestis monnieri* or Water hyssop is considered as important therapeutic plants of the Indian Medicinal System.[6] The name *B. monnieri* (*Brahmi*) (as shown in fig. 1) is derived from "*Brahma*", the legendary "creator" in the Hindu pantheon. Since the cerebrum is responsible for creative activity, any material that enhances the mind capability is called *B. monnieri* (*Brahmi*), which additionally signifies "bringing information on the incomparable reality" in India.[7] The plant comes under the endangered category due to its overexploitation for the medicine.[8-10] It has various medicinal properties like an anti-inflammatory, analgesic, antipyretic, sedative, antiepileptic and antioxidant, immuno-modulatory, memory enhancing, anti-stress, antianxiety, and anti-cancer.[11-14] In a new report, *B. monnieri* comes under the second position in Indian therapeutic plants based on medicinal significance, business esteem and research and development.[15,16] As per the National Therapeutic Plants Board Report, the yearly market interest for *Brahmi (Bacopa monnieri)* is around 1,000 tons in 2000, which build up its development because of its possible uses in Ayurvedic medicines to treat a variety of ailments[17]. Table no. 1 & 2 represents the taxonomical classification[18] and vernacular names[19-21] of *Brahmi* plant.

Figure 1: *Bacopa monnieri*

Table 1: Taxonomy of *Brahmi (Baccopa monnieri)*

Taxonomical Rank	Taxon
Kingdom	Plantae
Division	Anthophyta
Class	Dicotyledoneae
Order	Scrophulariales
Family	*Scrophulariaceae*
Genus	*Bacopa*
Species	*monniera*
Common name	Brahmi

Table 2: Vernacular names

English	Water hyssop, Indian pennywort, Thyme Leaved Gratiola
Sanskrit	Nir-brahmi, Brahmi, Aindri
Hindi	Brahmi, adha birni, Jal-brahmi, Sarasvati, Mandukaparni
Arabic	Farfakh
Assamese	Brahmi
Bengali	Aaghabini, Brihmi-sak, Jalanimba
Urdu	Brahmi
Kannada	Nirubrahmi
Telugu	Sambranichettu
Chinese	Jia ma chi xian
French	Petite bacopa
German	Kleine fettblatt
Gujrati	Baam
Hebrew	Psheta Srua
Japanese	Bakopa
Malayalam	Barna
Marathi	Ghola, Jalnam, Brahmi, Brahmi
Nepalese	Medha giree
Polish	Bakopa drobnolistna
Punjabi	Brahmibuti
Sanskrit	Adha birni
Tamil	Ahaznda poozndu
Telugu	Neeri sambraani mokka
Thai	Phrommi
Vietnamese	Rau dang bien

Botanical Description

Bacopa monnieri is a perennial non-aromatic herb. It is little smooth crawling beefy plant with numerous branches. It develops up to a height of 60-90cm and its branches are 5-35cm long. Roots are thin, wiry, little, expanded creamish-yellow. Seeds are infinite, irregular, or oblong. The stem is delicate, green or purplish-green, around 1mm thick, consists of nodes and internodes and the taste is slightly bitter. Leaves are bent, straightforward, inverse, crisscross, green, sessile, 8-15mm long, 4mm wide, elongated, dots are present on the lower surface with minute specks. Flowers are small, axillary, five-petaled, white, purple, pink, or pale violet in appearance. The pedicels are 6-30mm long; bracteoles present are narrow than pedicels. Fruits are like containers up to 5mm long, ovoid, glabrous, sharp at the apex and are purple in fresh condition. [22-26]

Geographical Distribution

This plant generally grows in wet soil, shallow water, and swamps. It is mainly found in countries like Nepal, India, Srilanka, China, Taiwan, Pakistan, Vietnam, Florida and the Southern region of the USA. In India, it is mainly found in tropical regions. It is dispersed in warmer regions of the world except India.[27-30]

Phytochemical Constituents of *Bacopa Monnieri*

The chemical constituents of *Bacopa monnieri* are alkaloids, brahmine and herpestine. The major phytochemicals reported are saponins, terpenoids[31] monnierin, hersaponin, tannins, flavonoids[32] glycosides[33] Bacoside A and bacoside B. Saponins are classified as pseudojujubogenin and jujubogenin glycosides and are reported as an important part of the plant.[34] Bacosides A and B have been known for memory-enhancing while Bacoside A possesses nitric oxide that permits the lightening of the aorta and veins in order to enhance the blood flow more freely throughout the body and making this significant plant a nootropic drug.[35] *Brahmi* constituents are also known to have anti-carcinogenic properties.[36] The saponin consists of bacoside A, bacoside B, betulin acid, D-mannitol, stigmastanol, β sitosterol, and stigmasterol.[37] The other phytochemicals

present are 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-glucopyranosy, l-3 β-Dglucopyranosyl, jujubogenin, 3-O-β-D-glucopyranosyl, l-3-β-D-glucopyranosyl, pseudojujubogenin, betulinic acid, wogonin, oroxidin, luteolin, luteolin 7-glucoside, luteolin-7-glucuronide, apigenin7-glucuronide and nicotine, 3-formyl-4-hydroxy-2H-pyran, bacosine, bacostcrol, bacosterol-3-O-β-D-glucopyranoside, stigmasterol, stigmastanol, β-sitosterol, D-mannitol, and an uncharacterized glycoside.[38,39] Figure 2 represents the chemical structure of Bacoside A and Bacoside B.

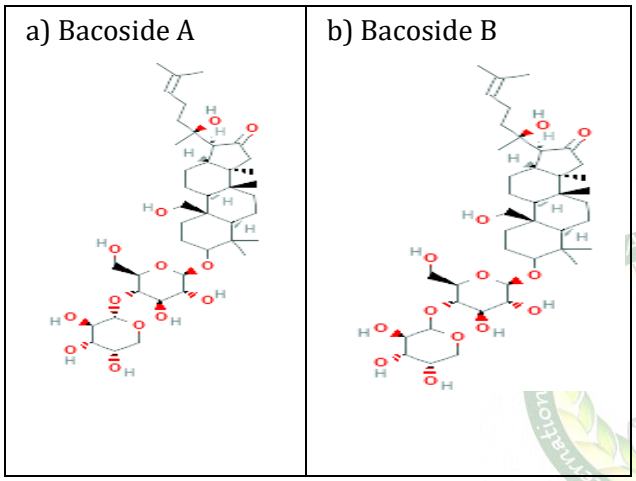

Figure 2: Chemical structures of Bacoside A and Bacoside B

Folk Uses

Traditional medicines play an important role among rural areas in many countries for the arrangement of medical services in the absence of an essential health care system.[40-43] *Bacopa monnieri* is utilized by various cultures around the world which shows its diverse ethnobotany. Also, the Thari people of the Nara Desert, Sindh, Pakistan use this medicinal herb as a blood purifier. They use to utilize the whole plant in powdered form for the purification of blood.[44] This plant plays an important role in the traditional medicinal system of Rajasthan. It is used against varieties of problems like stomach problems, bone fracture, asthma, Urinary duct inflammation, rheumatism, bronchitis, swelling of legs, Memory enhancement, Hoarseness of voice, blisters. Joyawake tea (a combination of *B. monnieri* and *Camellia sinensis*) is also used as a nervine tonic. The root extracts of this plant are used as an antivenom.[45] In Orissa, the leaves of this plant are used against cough, cold and nasal congestion. The root extract is utilized as an eye drop to treat cataracts and the leaves are used to treat constipation and asthma. They use this plant to treat headaches either in oil form or in paste form. They also utilize this as an antiseptic.[46] The people of Southern Western Ghats of Virudhunagar district, Tamil Nadu use *Brahmi* against Dysentery. They use this plant as a memory enhancer.[47] The root and leaf of this plant are used in the Villages of Dakshin Dinajpur, West Bengal to increase memory and against nervous disorder.[48] *B. monnieri* leaves are used by Malayan tribes of Southern Kerala for urine problems and to stimulate the pubic abdominal region.[49] In Bangladesh leaves are administered orally by some tribal people to purify the blood.[50]

Ayurvedic Literature on *Brahmi*

Brahmi (Bacopa monnieri Linn) is a very important herb in Ayurveda. It was initially described by Charaka Samhita, Atharva-Ved and Susurtu Samhita in their books.[51] It has been utilized as a therapeutic spice in Ayurveda since ancient times. It is used for the treatment of epilepsy, asthma, ulcers, and tumors.[52] It is described as a "*Medhya Rasayan*" drug (as indicated by "Ayurveda", the Indian traditional system of medicines, "*Medhyarasayanas*" possess natural therapeutic properties that support memory, re-establish intellectual deficiencies and enhance mental capacity) which is utilized to enhance memory. Intellect (*Medhya*), has been utilized by Ayurveda clinical experts in India for around 3000 years.[53,54] It plays a vital role in Ayurveda for the treatment of psychological problems of aging.[55,56] Bacopa plant is a significant element of the Ayurveda system, for example, *Brahmighritam*, *Brahmirasayanam*, and others. *Brahmirasayan* and *Brahmigritham* have been in use for quite a long time to control seizures in Ayurveda.[57] *Brahmi* is perhaps the most generally used herbs, the neurocognitive effects of which are well established. The herb is commonly used by Ayurveda to prepare polyherbal medicines like *Saraswatarishta* (SW) and *Brahmi Ghrita* (BG), *Saraswat Choorna* and others.[58,59] *Ras panchak* i.e., properties of *Brahmi* as per Ayurvedic literature is shown in table 1.

Table 3: *Rasa Panchak* (properties) of *Brahmi* as per Ayurveda[60]

Sanskrit /English	Sanskrit /English
Virya/Potency	*Sheeta*/Cold
Vipak/Metabolic property	*Madhura*/Sweet
Guna/Physical property	*Laghu*/Light
Rasa/Taste	*Tikta*/Bitter

Ayurvedic Action of *Brahmi* (*Baccopa monnieri)* [61,62]

Vatahara- Calms *Vata* (maintain the circulatory system)

Anuloma- Redirects the flow of *Vata* (blood flow) downwards

Unmadahara- Reduces mental illness

Pradnya shakti- Increases intellectual power

Hridya- Heart tonic

Majjadhatu Rasayana- Rejuvenative, particularly used to treat nervous system disorders.

Ayushya vardhana- Increases longevity

Balyam -Gives strength (especially to the mind)

Jeevaniya -Promotes energy

Medhya -Nervine

Nidrajnana- Promotes sleep

Kushtaghna -Alleviate skin conditions

Modern view on *Brahmi (Baccopa Monnieri)*

The adulteration in standard medicines is a rising issue in the herbal drug industry. It affects the business exertion of traditional herbal medicines. Breaking down in market assets is perhaps the greatest disadvantage in the improvement of herbal plant products.[63,64] The herbal products believe in a holistic approach where allopathic medicines work only upon suppressing the disease symptoms by using various chemically modified drugs. The allopathic medicines may have quick results but they can affect the immune system that is the major drawback of allopathic medicines. It is now evident that accessible therapeutic use doesn't satisfy the needs of patients facing various problems but corresponding to this traditional drug are considered as the most effective drugs with fewer side-effects. So instead of using allopathic drugs we can consider Ayurveda products of herbal plants for the treatment and prevention of various human body disorders. The herbal plant *Bacopa monnieri* possess memory enhancing property. It is used to cure other brain-related disorders like Alzheimer disease and other psychological disorders like anxiety and depression.[65]

Therapeutic Uses of *Brahmi*

There are many reported studies on pharmacological activity of *Brahmi* as shown in table no. 3.

Table 4: Reported Pharmacological Activities of *Brahmi*

Anti-Asthmatic Activity	*B. Monnieri* extract is reported to possess relaxant property in the tracheal muscle. It is also helpful in producing bronco dilation. The bronchodilator property of this plant may be reflected by the antagonism of carbachol-induced effects on inspiratory and expiratory stress.[66-69]
Anti-allergy	It has been reported that the methanolic extract of *B. Monnieri* possesses an intense mast cell stabilizer, showing the possible use of *B. Monnieri* leaves in allergic conditions.[70]
Anti- cancer activity	Bacoside A and B present in the ethanolic extract of B. monnieri plant possess anti-tumour property. Cucurbitacins component present in this plan were reported for their strong anti-tumorigenic and anti-proliferative activity.[71-73]
Anticonvulsive	In various scientific studies, it was reported that crude water extract of *B. Monnieri* controls epilepsy. The plant extract produces a sedative. Those substances which stimulates neurotransmitter GABA are known to possess anticonvulsant, pain-relieving and sedative effects.[74-76]
Antidepressant	*Bacopa monneri* is mainly known as a brain stabilizing agent. Methanolic extract of this plant possesses anti-depressant properties [77].
Anti-inflammatory	*Bacopa monneri* can release proinflammatory mediators through modulation. The triterpenoids and bacosides extract give effectiveness in the healing of various inflammatory conditions.[78-80]
Anti-nociceptive activity	The aqueous extract of the plant shows pain-relieving activity through various pathways, for example, β1-adrenergic, α2- adrenergic receptors and 5-HT receptors.[81]
Antioxidant activity	The anti-oxidant properties present in the alcoholic and hexane constituents of *B. monnieri* inhibit the lipid peroxidation effect.[82] Other scientific studies also showed the antioxidant effect of *B. monnieri* by other mechanisms. i.e., by inhibition of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX) activities.[83,84] The methanolic extract can restrain the superoxide anion

	concentration because of the decreased nitric oxide (NO which are used in various diseases like AD, ischemia.[85,86]
Anti-Spasmodic Activity	BM plant extract possesses spasmolytic activity in smooth muscles because of the hindrance of calcium influx via both voltage and receptor-worked calcium channels of the membrane.[87]
Anxiolytic effect	This plant has an important significance over lorazepam (LZP) since it does not induce amnesia and possess memory enhancing property too along with its anxiolytic activity.[88-90]
Cardiovascular activity	The ethanolic extract of the plant possesses cardiovascular property[91]. It maintains the blood flow by contracting the left ventricle. It also possesses to have a defensive effect on aspiratory and aorta.[92]
Gastroprotective activity	It is very useful in intestinal spasms e.g. Irritable bowel syndrome.[93,94] The juice and the extracts of the plant have been reported to have anti-ulcer properties. [95,96,97] The juice gives a gastroprotective effect as a result of which the mucosal membrane enhances the mucin secretion, and reduce cell shedding.[97]
Hepatoprotective activity	From the reported studies it was found that Bacoside present in the ethanolic extract of *B. monnieri* possess hepatoprotective activity when tested against albino mice.[98] Bacoside A plays an important role to prevent the elevation of LPO and activity of serum marker enzymes.[99]
Memory enhancer in Alzheimer's disease and Schizophrenia	The plant is mainly explored in the research area for its neuropharmacological potential and various reports have proved their nootropic action.[100-102] The alcoholic extract of Bacosides A and B enhance the learning ability of brain. BM has been known to improve protein kinase activity in the hippocampus.[103-105] It was also studied that it improves the learning ability when tested in mice.[106]

CONCLUSION

Bacopa monnieri is considered as the major traditional plant which is used to prepare various Ayurveda and Folk medicines. It shows huge potential in the enhancement of different neuro-pharmacological disorders, aggravation and other problems. The methanolic and ethanolic extracts of B. Monnieri are used to be a significant part of traditional medicinal system for treating various diseases. Also, Bacoside A is considered the most important phytochemical extracted from this plant which issued to prepare various therapeutic medicines. *Brahmi* is known to have anticancer, antidiabetic, mitigating, antimicrobial and anti-oxidant and memory-enhancing properties. It is thus concluded from the literature that *Bacopa monnieri* is a valuable medicinal herb that is being used in Ayurvedic traditional system for the treatment of vast human disorders.

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