

PHYTO-PHARMACOLOGICAL REVIEW OF *BACOPA MONNIERI* LINN

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ABSTRACT

Bacopa monnieri (L.), (Family Scrophulariaceae) is an important medicinal plant for the Indian traditional Ayurvedic medicine. Almost all of its parts are used in preparing medicine including leaves, stems and flowers. The review reveals phytochemical constituents isolated from the plant which possess pharmacological properties like memory enhancing, tranquilization, cardiovascular effects, sedative, antidepressant, antioxidant, cognitive, anticancer, antianxiety, adaptogenic, antiepileptic, gastrointestinal effects, endocrine, smooth muscle relaxant effects, analgesic, antipyretic, antidiabetic, antiarthritic, antihypertensive and antimicrobial effects with various other important medicinal properties. The whole plant of *B. monnieri* is used to treat skin diseases and as an antimicrobial agent. In the last few decades, extensive research has been done to confirm its biological activities and pharmacological properties. The article provides an account of updated information on its phytochemical and pharmacological properties of *B. monnieri*.

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INTRODUCTION

It is a small perennial herbaceous plant commonly known as 'Brahmi', belonging to the family Scrophulariaceae. This popular Indian medicinal plant has been used as a memory booster in Ayurvedic medicine for many years. *B. monnieri* contains alkaloid brahmine, nicotine, herpestine, bacosides A and B, saponins A, B and C, triterpenoid saponins, stigmastanol, β -sitosterol, betulinic acid, D-mannitol, stigmasterol, α -alanine, aspartic acid, glutamic acid, serine and pseudo-jujubogenin glycoside.

It is an important constituent of medhya-rasayana, a class of plant drugs used for promoting mental health and intellect (medhya), and to provide relief to patients with anxiety or epileptic disorders (Sivarajan and Balachandran, 1994). Various publications report on the biological effects of Brahmi, especially on its therapeutic potential in the treatment or prevention of neurological diseases and improvement of higher order cognitive processes (Singh and Dhawan, 1997; Vohora *et al.*, 2000; Das *et al.*, 2002; Russo and Borrelli, 2005). Subsequent studies indicated that the cognition facilitating effect is due to the two active saponins, bacoside A and B present in the ethanol extract (Singh and Dhawan, 1992).

TAXONOMICAL CLASSIFICATION

Kingdom – Plantae
Subkingdom –Viridiplantae
Infra kingdom –Streptophyta
Super division – Embryophyta
Division –Tracheophyta
Subdivision – Spermatophytina
Class – Magnoliopsida
Subclass –Asteridae
Superorder – Asteranae
Order –Lamiales

Family –Plantaginaceae

Genus –Bacopa

Species - *Bacopa Monnieri* (ITIS, 2015).

NOMENCLATURE

Bacopa monnieri is native to India, Bangladesh and Southern Asia, and also grows in Australia, Europe, and Africa. The vernacular names of *B. monnieri* are Indian pennywort, water hyssop (English), farfakh (Arabic), brahmi (Assamese), aaghabini (Bengali), jia ma chi xian (Chinese), petite bacopa (French), kleine fettblatt (German), baam (Gujrati), psheta srua (Hebrew), adha birni (Hindi), bakopa (Japanese), jala brahmi (Kannada), barna (Malayalam), ghola (Marathi), medha giree (Nepalese), bakopa drobnolistna (Polish), brahmibuti (Punjabi), adha birni (Sanskrit), ahaznda poozndu (Tamil), neeri sambraani mokka (Telugu), phrommi (Thai), and rau dang bien (Vietnamese) (PMP, 2014).

PLANT DESCRIPTION AND MORPHOLOGY

Bacopa monnieri is a small, creeping herb with numerous branches, small oblong leaves, and light purple flowers. In India and the tropics it grows naturally in wet soil, shallow water, and marshes. The herb can be found at elevations from sea level to altitudes of 4,400 feet, and is easily cultivated if adequate water is available. Flowers and fruit appear in summer and the entire plant is used medicinally (Stough *et al.*, 2001). Roots are thin, wiry, small, branched creamish-yellow. Stem is thin, green or purplish green, about 1-2 mm thick, soft, nodes and internodes prominent, glabrous, taste, slightly bitter. Flowers are small, axillary and solitary, five petaled white, purple, pink or pale violet in color, pedicels 6-30 mm long, bracteoles shorter than pedicels. Fruits are capsules up to 5 mm long, ovoid, glabrous and sharp at apex (Trivedi Manisha *et al.*, 2011).



Figure 1 *Bacopa monnieri* plant and flower

TRADITIONAL USES

It is used in traditional medicine as treatment for various nervous disorders, digestive aid, improving learning, memory and concentration and to provide relief to patients with anxiety and skin disorders; specific uses include the treatment of asthma, insanity and epilepsy. The Bacopa herb, also called nootropic herb, helps in the repair of damaged neurons, neuronal synthesis, and the restoration of synaptic activity, and improves brain function.

CHEMICAL COMPOSITION

Chemical composition of brahmi per 100 gm: moisture 88.4 gm, protein 2.1 gm, fat 0.6 gm, car-

bohydrates 5.9 gm, crude fiber 1.05 gm, ash 1.9 gm, calcium 202 gm, phosphorus 16 gm, ascorbic acid 63 gm, nicotinic acid 0.3 gm, iron 7.8 gm, energy 38 cal.

HOW IT WORKS

Extracts of Brahmi (*Bacopa monnieri*) have been extensively investigated for their neuro pharmacological effects. There are some compounds such as Saponins and their bacosides present in Brahmi, which are responsible to enhance nerve impulse transmission (Stough *et al.*, 2001). The bacosides aid in repair of damaged neurons by enhancing kinase activity, neuronal synthesis and restoration of synaptic activity and ultimately nerve impulse transmission. In animals, Bacopa has a relaxant effect on pulmonary arteries, aorta, trachea, ileal and bronchial tissue, possibly mediated by inhibition of calcium ion influx into cell membranes (Malhotra *et al.*, 1959). Numerous clinical trials and studies have been performed by various researchers to check the nootropic effects of *Bacopa monnieri*.

PHYTOCHEMICAL SUBSTANCES

The extract of *B. monnieri* revealed the presence of tannins, flavonoids (Singh, 2012). *Bacopa monnieri* (Top) smooth creeping fleshy plant has numerous branches (Middle) showing roots, stems and leaves (Bottom) various sizes of leaves. (Pant *et al.*, 2015), glycosides (Sivaramakrishna *et al.*, 2005, Tothiam *et al.*, 2011), terpenoids, saponins (Zhou *et al.*, 2007, Phrompittayarat *et al.*, 2007, 2008), bacosides, bacopasides (Agrawal *et al.*, 2006), bacopa saponins (Mahato *et al.*, 2000), and steroids. The major chemical constituents isolated and characterized from *B. monnieri* are dammaranes of triterpenoid saponins with pseudojujubogenin glycosides or jujubogenin glycosides (Chakravarty *et al.*, 2001, 2003; Hou *et al.*, 2002

Kamonwannasit *et al.*, 2008).

PHARMACOLOGICAL PROPERTIES OF BACOPA MONNIERI L.

Compounds responsible for the pharmacological effects of Bacopa include Alkaloids, Saponins and Sterols. Many active constituents-the alkaloids, Brahmine and Herpestine, saponins, d-mannitol and hersaponin, acid A and monnierin-have been isolated before. Other active constituents have been identified as numerous bacosides and bacopa saponins (Kapoor *et al.*,1990, Chakravarty *et al.*, 2001). The aerial parts of the plant contain a large number of Saponin, Alkaloids and Sterols. But the chief constituents of Bacopa monnieri are tetracyclic triterpenoid saponins, Bacoside A and B. Among these, Bacoside A is predominant. Bacoside A and B have identical sapogeninandal and therefore have the same sugar moiety but Bacoside A and B differ only in optical rotation. On acid hydrolysis Bacoside A and B yield glucose, arabinose and bacogenin A1, A2, A3 and A4. A1 and A2 are the epimers. Bacogenin A4 is the major component. The other minor compounds includes Saponins viz., bacoside A1 and A3, hersaponin, monnierin, Alkaloids viz., herpestine and brahmine, Flavonoids viz., luteolin-7-glucoside, glucoronoyl-7-apigenin and glucoronoyl-7- luteolin, Phytosterols viz., stigmasterol, and beta sitosterol (Choudhuri and eIndian 2002)

MEMORY ENHANCEMENT

Behavioral studies in animals have shown that Bacopa improves motor learning, acquisition and retention, and delayed extinction of newly acquired behaviour (Singh *et al.*, 1997). The methanol extract and different fractions of *B. monnieri* were evaluated for antidepressant activity in the forced swimming test (FST) and tail suspension test (TST) in mice. The results showed that the methanol extract, ethanol and

butanol fraction were significantly reduced.

Test for mobility, both in FST and TST in mice after being administered orally for 5 consecutive days showed that in all tested samples, in the effective doses for FST and TST, showed no inhibitory effect against locomotor activity (LA) in mice (Shen *et al.*, 2009). On the other hand, it was found that bacosides facilitate anterograde memory and attenuate anterograde experimental amnesia induced by scopolamine and sodium nitrite possibly by improving the acetylcholine level and hypoxic conditions, respectively. In addition, bacosides also reversed BN52021 (a platelet-activating factor receptor antagonist) induced retrograde amnesia, probably due to increase in platelet activating factor synthesis by enhancing cerebral glutamate level (Choudhuri *et al.*,1996). Memory deficits following cholinergic blockade by scopolamine were reversed by Bacopa treatment. Bacopa improved memory functioning in cognitively intact cohorts, with Pycnogenol improving working memory (Ryan *et al.*, 2008). Benzodiazepines are known to produce amnesia by the involvement of the GABA ergic system and by the interference of long term potentiation. The behavioral study showed that Bacopa monniera significantly reversed diazepam induced amnesia (Saraf *et al.*, 2008). Bacopa administration with phenytoin significantly reversed phenytoin-induced cognitive impairment, as noted by improved acquisition and retention of memory (Vohora *et al.*, 2000). A clinical trial was carried out to assess the effects of 12- weeks administration of Bacopa monnieri (300mg/day) on memory performance in people over the age of 55- years. Bacopa significantly improved memory acquisition and retention in older persons (Morgan *et al.*, 2012). Significant cognitive enhancing benefits have been demonstrated with chronic administration of Bacopa extracts. A double-blind, placebo-controlled, 12-week trial utilizing the same patient selection criteria -

and the same dose of Bacopa extract (300 mg daily) containing 55% combined bacosides, was carried out. Forty-six healthy volunteers (ages 18-60) were randomly and evenly divided into treatment and placebo groups. The same series of tests administered in the acute dosage trial were administered at baseline, five, and 12 weeks after treatment began. At the end of the 12-week study, results indicated a significant improvement in verbal learning, memory consolidation, and speed of early information processing in the treatment group compared to placebo. These effects were not observed at baseline or at five weeks (Stough *et al.*, 2001). The Bacopa supplement was commercially available as KeenMind™ (Flordis). This product is manufactured from the stems, leaves and roots of Bacopa and is extracted with 50% ethanol. It is standardized to contain active bacosides at levels of 55% ± 5%. Keen Mind™ helps develop novel preventative health practices and nutritional/pharmacological targets in the elderly for cognitive and brain health. Bacopa appeared to have multiple modes of action in the brain, all of which may be useful in ameliorating cognitive decline in the elderly. These include: (i) direct pro-cholinergic action; (ii) anti-oxidant (flavonoid) activity; (iii) metal chelation; (iv) anti-inflammatory effects; (v) improved blood circulation; (vi) adaptogenic activity; and (vii) removal of b-amyloid deposits. (Stough *et al.*, 2012). However, in a double-blind randomized, placebo control study performed on 76 adults aged between 40 and 65 years, in which various memory functions were tested and levels of anxiety was measured, the rate of learning was unaffected by Bacopa monnieri suggesting that *Bacopa monnieri* decreases the rate of forgetting of newly acquired information. Tasks assessing attention, verbal and visual short-term memory and the retrieval of pre-experimental knowledge were unaffected. Questionnaire measures of everyday memory function and anxiety levels were also unaffected (Roodenrys *et al.*, 2002).

ANXIETY AND DEPRESSION

Both animal and clinical research support Bacopa's traditional use as a remedy for anxiety in Ayurveda. Research using Bacopa extract of 25% bacoside A confirmed better anxiolytic activity comparable to Lorazepam (Bhattacharya *et al.*, 1998). Importantly, the extract did not show any side effects but instead had a memory-enhancing effect. A one-month study involving diagnosed anxiety patients with Brahmi syrup resulted in a significant decrease in anxiety symptoms and level of anxiety (Singh *et al.*, 1980).

BRONCHITIS AND ASTHMA

Animal studies show that Bacopa extracts have a relaxant effect on chemically induced bronchoconstriction. An earlier in-vitro study demonstrated that methanol extract of bacopa possessed potent mast cell stabilizing activity comparable to disodium cromoglycate (a commonly used allergy medication). This study indicates the potential usefulness of Bacopa extract in bronchoconstrictive conditions as well as some allergic conditions (Samiulla *et al.*, 2001).

GASTROINTESTINAL DISORDERS

In vitro, animal studies have investigated the effects of Bacopa extract on gastrointestinal tract demonstrating direct spasmolytic activity on intestinal smooth muscle (Dar and Channa, 1999). The study suggests the protective and curative effects on gastric ulcers. A recent *in vitro* study of Bacopa extract demonstrated antimicrobial activity against *Helicobacter pylori*, the bacteria responsible for chronic gastric ulcers (Goel *et al.*, 2003).

CARDIOVASCULAR EFFECTS

Use of *Bacopa* as a cardiogenic has been frequently mentioned in Ayurvedic medicine literature. *In vitro* research using rabbit aorta and pulmonary artery demonstrated that *Bacopa* extract has a vasodilatory effect interfering with calcium channel flux in tissue cells (Dar and Channa 1999).

CONCLUSION

The phytochemical and pharmacological properties of *Bacopa monnieri* showed potential applications in medical science and could be more in the future upon extensive study on this important medicinal plant.

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