PHARMACOGNOSTIC AND PHARMACOLOGICAL ASPECT OF BACOPA MONNIERI: A REVIEW

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ABSTRACT

It is said that the use of Bacopa monnieri (BM) for memory enhancement goes back 3000 years or more in India, when it was cited for its medicinal properties, especially the memory enhancing capacity, in the vedic texts “Athar-Ved Samhila” (3:1) of 800 BC and in Ayurveda. In the folklore of Indian medicine, several herbs have been used traditionally as brain or nerve tonics. One of the most popular of these neurotonics is BM, a well-known memory booster. Brahmi has been administered at religious institutions to help students to enhance their memory for learning ancient, religious hymns. It is also used as cardio-tonic, tranquilizer and sedative, improves the process of learning, restores memory, and enhances power of speech and imagination, diuretic and nervine tonic, antistress, for nervous and mental strain, use in insanity, epilepsy, hysteria, esthenia, nervous breakdown.

Keywords: Ayurveda, Brahmi, Memory booster, Herb, Neurotonics, Tranquilizer.

INTRODUCTION

Herbal drugs constitute only those traditional medicines which primarily use medicinal plant preparations for therapy. The earliest recorded evidence of their use in Indian, Chinese, Egyptian, Greek, Roman, and Syrian texts dates back to about 5000 years. The classical Indian texts include Rigveda, Atharvaveda, Charak Samhita, and Sushruta Samhita. The herbal medicines/traditional medicaments have, therefore, been derived from rich traditions of ancient civilizations and scientific heritage.

Description of the herb
Bacopa monnieri (BM) is a small, creeping, somewhat succulent herb. The leaf and flower bearing stems are 10-30 cm long and arise from creeping stems that form roots at the nodes. The growth habit of Bacopa, therefore, resembles that of peppermint. The leaves are simple, obovate-oblong, opposite, approximately 2 cm × 1 cm, with entire margins, flowers are blue or white with purple veins, solitarily on long pedicels in the leaf axils. The corolla is five lobed, white or pinkish with purple blotches. The fruit is an up to 5 mm capsule, which develops in the persistent calyx (Fig. 1). Bacopa is a member of the family Scrophulariaceae [1,2].

Macroscopic
The plant is succulent when fresh but becomes shriveled on drying slightly bitter in taste, without any characteristic odor and composed of crumpled, matted broken pieces of roots, branching stems, leaves, flowers, and few tender fruits [3,4].

Leaf
Simple, opposite and decussate, somewhat sessile, glabrous, obovate-oblongo to spatulate in shape, 0.6-2.5 cm in length and 3-8 mm in width, entire, lower surface dotted with minute specks, obscurely 1-3 nerved, color faint green [5].

Flower
Pale blue or pinkish white, nearly regular, solitary, axillary. 0.6-3 cm 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 [6,7].

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

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

Microscopic
Root
The root is irregularly circular to angular in shape and show an outermost piliferous layer, parenchymatous cortex with intervening air spaces and a centrally located solid core, of xylem encircled by narrow phloem. The piliferous layer is replaced by formation of cork cells, cortex is wide, parenchymatous, traversed with simple and compound starch grain intervened with air spaces, endoderm is distinct, a narrow band of phloem surrounding the located solid core of xylem composed of radially arranged isolated vessels, fibers, and medullary rays (Fig. 2) [8,9].

Stem
The stem is almost circular in outline, shows outer epidermis, broad aerenchymatous cortex occupying the major area of the
section, a distinct endodermis encircling the ring of stellar tissue and central parenchymatous pith with a layer of thick-walled celled epidermis covered with thin cuticle, cortex is very wide, consisting of chlorenchymatous aerenchyma embedded with starch grains. Endodermis is distinct, encircling the narrow band of parenchymatous phloem and xylem, the central region being occupied by narrow parenchymatous pith embedded with simple and compound starch grains.

Leaf
The leaf passing through the midrib is almost cylindrical in outline with a very narrow elevation on the upper side of the midrib. Upper and lower epidermis, the cells of the upper being bigger in size and at places show striated cuticle, both the epidermis are embedded with stomata and bear sessile-glandular trichomes with multi cellular head. A narrow collenchymatous band is located underneath both the epidermis of the midrib and shows a centrally located conjoint collateral meristele encircled by a parenchymatous sheath. The mesophyll tissue of the lamina is composed of spongy parenchyma, traversed with vascular strands; prismatic and few cluster crystals of calcium oxalate are embedded throughout the parenchymatous cells of the leaf [7,10].

Powder
Shows fragments of upper and lower epidermis of leaf in surface view embedded with sessile-glandular trichomes with 4-8 celled head and diacitic to anomocytic stomata, they being more on the lower side, with sinuous anticlinical walls and at places shows striated cuticle; prismatic, cluster crystals of calcium oxalate, starch grains and oil globules scattered as such throughout or embedded in the parenchymatous cells, transversely cut fragments of stem showing aerenchymatous cortical cells, papillose marginal cells of the petal, tests of the seed in surface view and transversely cut fragments of cotyledon [11].

Chemical constituents
Major
Bacoside A: The chief constituents are brahmine, herpestine, alkaloids, and saponins. The saponins designated as bacoside A, bacoside B, and betulic acid (Figs. 3 and 4). D-mannitol, stigmastanol, β-sitosterol, and stigma sterol have been isolated, bacoside A, on acid hydrolysis gave three sugars, two of which have been identified as glucose and arabinoose. Bacoside B also gave on hydrolysis glucose and arabinose [12].

Others

Quantitative standards [13]
Foreign matter: Not more than 2.0%.
Total ash: Not more than 7.0%.
Acid-insoluble ash: Not more than 2.0%.
Ethanol-soluble extractive: Not <40.0%.
Water-soluble extractive: Not <50.0%.
Moisture content: Not <80.0%.

PRELIMINARY PHYTOCHEMICAL SCREENING
The aqueous and ethanolic extract of BM (BME) was subjected to preliminary phytochemical investigation for the detection of the following metabolites (Table 1):
- Alkaloids
- Carbohydrates
- Glycosides

Fig. 1: Fresh and dried herb of *Bacopa monnieri*

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Fig. 2: (a) Vascular bundles, (b) parenchymatous cells, (c) calcium oxalate crystals, (d) xylem and phloem

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Fig. 3: Bacoside A

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Fig. 4: Bacoside B
In the study, the BME in the dose range of 20-40 mg/kg was
of depression, namely, forced swim test and learned helpless
ness. The defatted-alcoholic extract (2-4 mg/kg b.w.) and crude aqueous extract
improvement and EEG changes in these two cases [17].

Table 1: Phytoconstituents present in aqueous extract of
BM [11,14]

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Phytoconstituent</th>
<th>Presence/absence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tannins</td>
<td>−ve</td>
</tr>
<tr>
<td>2</td>
<td>Saponins</td>
<td>+ve</td>
</tr>
<tr>
<td>3</td>
<td>Alkaloids</td>
<td>−ve</td>
</tr>
<tr>
<td>4</td>
<td>Carbohydrates</td>
<td>+ve</td>
</tr>
<tr>
<td>5</td>
<td>Protein</td>
<td>+ve</td>
</tr>
<tr>
<td>6</td>
<td>Sterols</td>
<td>−ve</td>
</tr>
<tr>
<td>7</td>
<td>Volatile oil</td>
<td>−ve</td>
</tr>
<tr>
<td>8</td>
<td>Flavonoids</td>
<td>+ve</td>
</tr>
<tr>
<td>9</td>
<td>Triterpenoids</td>
<td>+ve</td>
</tr>
<tr>
<td>10</td>
<td>Glycoside</td>
<td>+ve</td>
</tr>
<tr>
<td>11</td>
<td>Fixed Oil</td>
<td>−ve</td>
</tr>
</tbody>
</table>

+ve: Presence, −ve: Absence, BM: Bacopa monnieri

Pharmacology
Ethanol extract (10 mg/kg) brahmi improved motor learning in
drats. Both ethanol extract as well as the active principle hersaponin
exhibited tranquilizing activity. The active principle also induced the
concentration of noradrenaline and 5-hydroxytryptamine in brain.
Antianxiety effect was reported in ethanol extract and saponin in
rat. Antidepressant activity has also been reported. Ethanol extract
(50 mg/kg) was found to have antiagastic ulcer activity in normal and
diabetic rats and also had anti-Helicobacter pylori activity in vitro. Other
pharmacological activities reported were antioxidant, anticonvulsant,
anaesthetic, antiallergic, antifungal, cardiac depressant, and cardio-tonic
ether by crude extract or pure principle.

Major therapeutic claims
Antiepileptic, antipyretic, antidepressant, anti-inflammatory, and
anxiolytic [15].

Antiepileptic
A clinical study was undertaken with the crude aqueous and defatted
alcoholic extracts of the plant in 24 patients with varied mental
disorders. The study revealed improvement in learning process and
correction in the abnormal behavior of epileptic patients treated with
defatted-alcoholic extract (2-4 mg/kg b.w.) and crude aqueous extract of
"brahmi" two dose daily for 5 months. Defatted alcoholic extract of
"brahmi" was found to be more potent than the aqueous form in
allieving the epileptic fits [16]. A controlled clinical trial was carried
out with crude BMEs (4 patients), Marsilea minuta (2 patients), and
Acorus calamus (6 patients) in epileptic patients with special reference
to electroencephalography (EEG) changes to substantiate their sedative
and tranquilizing properties. The defatted alcoholic extract of "brahmi"
showed improvement in one case each of temporal lobe epilepsy and
petit mal epilepsy. There was a close parallelism between the clinical
improvement and EEG changes in these two cases [17].

Antianxiety and antidepressant activity
Research using a rat model of clinical anxiety demonstrated that a BME
containing 25% bacoside A exerted anxiolytic activity comparable to
diazepam, a common benzodiazepine anxiolytic drug, and it was
attentively noted that the BME did not induce amnesia, side effects
associated with diazepam, but instead had a memory-enhancing
 effect [18]. The antidepressant potential of BM has been evaluated in
an earlier study, wherein it showed a significant antidepressant activity
in the most commonly used behavior paradigms in animal models
deressmee, namely, forced swim test and learned helplessness
tests. In the study, the BME in the dose range of 20-40 mg/kg was
given once daily for 5 days, and it was found comparable to standard

didepressant drug imipramine in antidepressant activity in rodent
animals. The same study has postulated the role of serotonin and gamma
amino butyric acid (GABA) in the mechanism of action attributed for
its antidepressant action along with its anxiolytic potential, based on
the compelling evidence that the symptoms of anxiety and depression
overlap each other [19].

Memory enhancer
Efficacy of plant was studied in revitalizing intellectual functions in
40 school going children from rural area in Varanasi. One group was
given "brahmi" syrup one teaspoon full (350 mg), thrice daily for
3 months, and the other group was given syrup “simplex” used as
placebo in the same dose. There were renovation and improvement of
the perceptual-motor functions during the development phase in the
group receiving "brahmi". A double-blind controlled study was carried
out to evaluate the effect of a micro ("sukma") medicine derived from
the plant by 1 month treatment on 110 boy students in the age of 10-
13 years and having average IQ 100. The study showed encouraging
results in enhancing some factors of intelligence, viz., memory (direct),
arithmetic skill, and some verbal factors. Need for long-term study was
felt [20].

Sedative and tranquilizing properties
Earlier studies reported a sedative effect of glycosides named
hersaposins. A subsequent study has found that the alcoholic extract,
and to a lesser extent the aqueous extract of the whole plant exhibited
tranquilizing effects on albino rats and dogs. On the other hand, it has
been found that the alcoholic extract of the plant and chlorpromazine
improved the performance of rats in motor learning. A previous study
has reported that a single dose of the glycoside hersaponin is better than
pentobarbitone in facilitating acquisition and retention of brightness
discrimination reaction [21].

Central nervous system effects
Brahmi Rasayan, an ayurvedic preparation, was studied in mice and
rats for its effects on the central nervous system at oral doses ranging
between 1 and 30 g/kg. Observational screening in mice was carried
out following a multiparametric check list. The test material was
studied for its effect on pentobarbitone hypnosis, motor coordination,
tail-withdraws reaction time, electroshock, chemoconvulsions,
haloperidol-induced catalepsy and conditioned avoidance response.
The test material exhibited a sedative effect and significantly prolonged
the hypnotic action of pentobarbitone. It produced a variable blockade
of conditioned avoidance response. The presence of a significant
antidepressive effect, coupled with the ability of the test substance to
offer protection against electroshock seizures and chemoconvulsions
plus the ability to antagonize the haloperidol-induced catalepsy, suggests
an involvement of the GABAergic system in the mediation of
the central nervous system effects of Brahmi Rasayan [22].

Antioxidant and adaptogenic properties
BME or bacosides have shown an antioxidant activity and antistress
[21]. A previous study suggests an involvement of the GABAergic system in
the mediation of these central nervous system effects of BM [22]. Based
on animal study results, bacosides were shown to have antioxidant
activity in the hippocampus, frontal cortex, and striatum [23]. Animal
research has shown that the BMEMs modulate the expression of certain
enzymes involved in generation and scavenging of reactive oxygen
species in the brain. It was suggested that the adaptogenic properties
of the herb would be beneficial in the management of stress related
conditions as BM showed the potential to be effective in stress in a
study on rats [24]. In the study, BME was found not only to induce the
constitute expression of heat-shock protein 70 (Hsp70) but also induce
the mediation of these central nervous system effects of Brahmi Rasayan [22].

BME or bacosides have shown an antioxidant activity and antistress
Cigarette smoking is implicated as a major risk factor in the development of cardiovascular and cerebrovascular diseases. It has been associated with a higher risk of cardiovascular disease, including myocardial infarction and stroke. The mechanism by which cigarette smoking increases the risk of cardiovascular disease is not fully understood, but it is believed to involve the release of proinflammatory cytokines and oxidative stress, which contribute to the development and progression of atherosclerosis. These changes can lead to the formation of plaques in the arteries, which can eventually rupture and lead to the formation of clots, causing heart attacks or strokes.

Smokers are at a higher risk of developing cardiovascular disease because they have a higher prevalence of other risk factors, such as hypertension, dyslipidemia, and diabetes. Additionally, smoking increases the likelihood of developing other conditions that can contribute to cardiovascular disease, such as chronic obstructive pulmonary disease (COPD) and chronic obstructive pulmonary disease (COPD).

The health effects of smoking vary depending on the type of tobacco product used and the duration of exposure. For example, smoking cigarettes is associated with a higher risk of developing lung cancer, whereas the risk of developing oral cancer is higher among those who smoke pipes or chewing tobacco. Additionally, smoking increases the risk of developing several other cancers, including bladder cancer, kidney cancer, and stomach cancer.

Several factors can contribute to the development of smoking-related cardiovascular disease, including the presence of other risk factors, such as hypertension, obesity, and diabetes. Additionally, smoking can increase the risk of developing other conditions that can contribute to cardiovascular disease, such as chronic obstructive pulmonary disease (COPD) and chronic obstructive pulmonary disease (COPD).

The risk of developing smoking-related cardiovascular disease can be reduced by quitting smoking. Quitting smoking can help to reduce the risk of developing these conditions and improve overall health outcomes. Additionally, individuals who quit smoking can expect to see improvements in their physical and mental well-being, as well as a reduction in the risk of developing other smoking-related health problems.
demonstrated its specific antimicrobial activity against *H. pylori*, a bacterium associated with chronic gastric ulcers. When the extract was incubated with human colonic mucosal cells and *H. pylori*, it resulted in the accumulation of prostaglandin E and prostacyclin, prostaglandins known to be protective for gastric mucosa.

**Anticonvulsant**

Crude plant extract of BM or bacosides has also shown anticonvulsant action. It possessed neuroprotective effects in glutamate-mediated excitotoxicity during seizures and cognitive damage occurring in association with pilocarpine-induced epilepsy. The ethanolic extract of BM was tested for anticonvulsant activity using different convulsant models (pentyleneetrazol, maximal electroshock, and strychnine-induced convulsions in rats, as well as hypoxic stress-induced convulsions in mice and lithium-pilocarpine-induced status epilepticus). The ethanolic extract of BM was administered as 50-55 mg/kg orally for rats and mice, respectively, 2 and 4 hours before the respective convulsive stimuli. The ethanolic extract of leaves produced significant anticonvulsant activity for all the different models studied with a mechanism of action similar to that of benzodiazepines (GABA agonist) [16,18].

**Safety aspects**

The drug used in traditionally prescribed doses may be considered safe.

**Dose**

Powder: 1-3 g.

**REFERENCES**