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# REVIEW ON INVITRO ACTIVITY OF ANTI-INFLAMMATORY, ANTI-MICROBIAL AND ANTI-FUNGAL ON BACOPA MONNIERI

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***Abstract:*** The aim of the present study was to investigate the phytochemical profile as well as the anti-microbial, anti-fungal and anti-inflammatory properties of Bacopa monnieri. Most traditional natural products are getting more popular. Natural products continue to produce bioactive agents because of the amazing chemical diversity that is readily available. They were assessed as potential therapeutic candidates for the treatment of infectious illnesses in both humans and animals. 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.

***Index Terms*: Bacopa monnieri, anti-microbial, anti-fungal and anti-inflammatory properties**.

## I. INTRODUCTION

Bacopa monnieri L. (Family: Scrophulariaceae), commonly known as 'Brahmi', is a perennial and semi-succulent herb which grows in wet, damp, and marshy areas throughout India. 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.

*Figure 1: Bacopa Monnieri*

Bacopa monnieri is a part of the Scrophulariaceae family and is also referred to as aindri and brahmi in Sanskrit. This herb grows up to 1500 metres high in moist regions of neighbouring tropical countries and

India. It is glabrous, creeper-like, and somewhat succulent.Bacopa's reputation as medhya rasayana stems from its capacity to enhance cognitive qualities of the brain and is an herb that all Ayurvedic practitioners utilise frequently. To address illnesses like fever, inflammation, pain, asthma, epilepsy, and memory decline. The primary chemical element accountable for these. A triterpenoid saponin of the dammarane class with neuropharmacological effects is known as bacoside an aglycone is composed of jujubogenin or pseudo-jujubogenin moieties measures. Bacoside A is made up of jujubogenin isomer of bacopaside II, bacoside A3, andbacopaside X, bacopasaponin C, and both. Considering the structural resemblance, 12Analogues belonging to the bacoside family have been clarified. Not so long ago, dierent. It has been determined that some saponin classes are significant components of the herbal extract which go under the names bacopasides I–XII . There have also been reports of the plant containing Cucurbitacin, apigenin, D-mannitol, monnierasides I–III, hersaponin, and plantainosideB and alkaloids such as herpestine, nicotine, brahmine, and monnierin. The Significant quantities of avanoids and provide high antioxidant properties. The herb contains phenolic chemicals.

Inflammation usually occurs when infectious microorganisms such as bacteria, viruses, or fungi invade the body, reside in particular tissues, and or circulate in the blood. Inflammation may also happen in response to processes such as tissue injury, cell death, cancer, ischemia and degeneration. Mostly, both the innate immune response as well as the adaptive immune response is involved in the formation of inflammation. The innate immune system is the foremost defense mechanism against invading microorganisms and cancer cells, involving the activity of various cells including macrophages, mast cells, and dendritic cells. The adaptiveimmune systems involve the activity of more specialized cells such as B and T cells who are responsible for eradicating invading pathogens and cancer cells by producing specific receptors and antibodies. Numerous inflammatorymediators are synthesized andsecreted during inflammatory responses of different types. Inflammatory substances are usually divided into two maincategories: pro- and anti-inflammatory mediators. Nevertheless, some mediators such as interleukin (IL)-12 possess both pro-and anti-inflammatory properties.

## II.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.

## III. PLANT PROFILE:

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Lamiales
Family : Scrophulariaceae
Genus : Bacopa
Species : B. Monnieri

**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 |
| Punjabi | - | Brahmibuti |
| Sanskrit | - | Adha birni |
| Tamil | - | Ahaznda poozndu |
| Telugu | - | Neeri sambraani mokka |

## IV. MACROSCOPICCHARACTERS*:*

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.

***a)Root***

Fragments of dried main roots are cylindrical, about 5 mm in diameter, longitudinally wrinkled and off-white in color.

***b) 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 1-1.5 cm in length and 3-4 mm in diameter, pale yellowish green and with purplish tinge.

## V. CHEMICAL CONSTITUENTS

***a) MajorConstituents***: Bacoside A: The chief constituents are brahmine, herpestine, alkaloids, and saponins. The saponins designated as bacoside A, bacoside B, and betulic acid. 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 arabinose bacoside B also gave on hydrolysis glucose and arabinose.

***b) 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 glycoside.

## VI. PHARMACOLOGICAL PROPERTIES OF BACOPA MONNIERI

***a) Antimicrobial effect:***

The antibacterial activity of BM was screened for different bacterial strains using methanol, ethanol, chloroform, and petroleum ether. The phytochemical screening was carried out to know the compounds responsible for these activities. Methanol, ethanol, and chloroform extracts were tested against Bacillus amyloliquefaciens (MTCC 1270), Streptococcus pyogens (MTCC 1923), Vulgarica, Bacillus megaterium (MTCC 3353), Aspergillus niger (MTCC 281), Bacillus pumilus, Salmonella typhi, Bacillus subtilis, and Micrococcus luteus. The susceptibility of the bacteria to the crude extracts on the basis of zones of growth inhibition varied according to microorganism and extracting solvent. In most of the above-mentioned plants, the methanol extract produced the highest activity. On the basis of the results obtained, it could be concluded that methanol could be used for extracting antimicrobial compounds from leaves. When compared to other extracts, methanol extracts were discovered to be the most effective antibacterial agents. 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 found to have the lowest minimum inhibitory concentration (MIC) against Salmonella typhimurium, E. coli, Staphylococcus aureus, and Saccharomyces cerevisae. Maximum activity was reported against Staphylococcus aureus, and good activity was observed against Salmonella typhi, E. coli, and Staphylococcus aureus in the methanolic extract (1 mg/ml) of Bacopa monnieri callus. There was no evidence of K. pneumoniae activity. Salmonella typhi, Pseudomonas aeruginos, Staphylococcus aureus, Vibrio cholera, and Candida albicans were among the four bacteria and one fungus that the ether extract of Bacopa monnieri demonstrated antibacterial efficacy against.

***b) Anti-inflammatory Activity:***

Nonsteroidal anti-inflammatory drugs (NSAIDs) are medications that relieve or reducepain. The most popular examples of drugs in this group are aspirin and ibuprofen.NSAIDs come under the wider definition of non-opioidanalgesics. At anti-inflammatory concentrations, bacopa monniera did not irritate the stomach and successfully reduced the effect of an experimentally produced inflammatory reaction by partially stabilizing lyosomal membranes and by reducing the generation of prostaglandins. At oral doses of 250 and 500 mg/kg ($P<0.001$), the ethanol extract of the entire Bacopa monnieri plant significantly reduced writhing in mice triggered by acetic acid, in a manner similar to that of diclofenac sodium 25 mg/kg. Several Bacopa monnieri extracts' anti-inflammatory properties were studied in rat hindpaw edema caused by carrageenan. The edema paw volume was significantly reduced by the methanol extract and aqueous fractions (100 mg/kg), while the inflammation was not reduced by petroleum ether or hexane extracts.The in vitro anti-inflammatory effect of Bacopa monnieri was assessed using the human red blood cell (HRBC) membrane stabilization method. Diclofenac sodium was not as effective at producing membrane stability as methanolic extract and the callus (100, 200, and 300 µg).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. Pro-inflammatory cytokines, including interleukin-6 and tumor necrosis factor-alpha, were not produced by the fractions containing bacosides and triterpenoids.

***c) Antioxidant and antifungal properties***

BME or bacosides have shown an antioxidant activity and antistress. A previous study suggests an involvement of the GABAergic system in the mediation of these central nervous system effects of BM. Based on animal study results, bacosides were shown to have antioxidant activity in the hippocampus, frontal cortex, and striatum. Animal research has shown that the BMEs 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. In the study, BME was found not only to induce the constitute expression of heat-shock protein 70 (Hsp70) but also induce the cytochrome P450 (CYP 450) enzymes in all regions of the brain. The level of Hsp70 was found to be increased in the brain as a response to stress. On the other hand, the group that was pre-treated for 1 week

with 20-40 mg/kg/daily, before giving stress, the Hsp70 was found to be in lower concentration.Plant extract's antifungal activity was tested by Jain et al. against Alternaria species, Fusarium oxysporum, Rhizocotonia solani, and Sclerotium rolfsii. The antifungal activity of plant extract was tested at various doses. Following autoclaving, several concentrations of plant extract—12.5µg/ml, 25µg/ml, 37.5µg/ml, 50µg/ml, and 62.5µg/ml—were added to the PDA media. Plant extract has been observed to provide 100% inhibition against Fusarium oxysprum, Sclerotium rolfsii, Alternaria species, and Rhizootonia solani at dosages of 50µg/ml and 62.5µg/ml. According to the data, the plant's IC50 value against Fusarium oxysprum was 31.25 g/mL. At 25 µg/ml, Sclerotium rolfsii demonstrated 90% inhibition, demonstrating superior antifungal efficacy. The IC50 value for Sclerotium rolfsii has been documented as 6.25 µg/ml, while the IC50 value for Alternaria has been recorded as 28.75 g/ml and 18.75 g/ml.

**Invitro Study**

In about twenty percent of the published studies on B. monnieri micro propagation, direct shoot organogenesis has been used to regenerate entire plants using leaf and internode explants from in vitro produced plants. Direct adventitious shoot regeneration (~80 shoots/leaf explants) on MS medium supplemented with BA (6-benzylamino purine) was reported by Tiwari et al. In a subsequent paper, Tiwari et al. observed that utilizing TDZ in place of BA in the shoot induction medium (SIM) increased the rate of adventitious shoot bud development (93 shoot buds/leaf explant in seven days). After three subcultures on shoot multiplication medium (SMM) supplemented with BA, there were more adventitious shoot buds/leaf explants produced (~130).Many plants' morphology and regeneration have been shown to be affected by the cytokinin-like impact of TDZ in vitro. Its exact mechanism of action and function during the inductive stage of in vitro morphogenesis are unknown, though. It has also been found that the fungicide BVN (Bavistin) and antibiotic TMP (Trimethoprim) promote de novo shoot organogenesis. By employing TDZ and NAA (α-naphthaleneacetic acid), Ceasar et al. were able to induce 49 and 56 shoots/internode and leaf explants, respectively. After transferring the plants to SMM with low levels of BA, the rate of shoot multiplication increased significantly, reaching roughly 135 shoots/leaf explant and 112 shoots/internode explant.A few years ago, reported on the promotive action of spermidine in combination with BA in adventitious shoot bud induction from mature leaves plucked from in vitro grown plants. Explants from tissue culture-raised plants are then used to induce shoot regeneration, resulting in the development of over 100 rooted plants/explant in a matter of 8–12 weeks, with 85%–100% survival in the field following acclimatization.

Although the morphogenic potential of *B. monnieri* explants appears to be very high, as evident in most of studies, the choice of explants and regeneration protocol will be important for maintaining genetic stability avoiding somaclonal variations. Hence, it is suggested that both axillary bud multiplication and adventitious bud induction using leaf explants (without intervening callus phase) can be explant of choice using cytokinins like BA and TDZ as reported. A novel technique for the production of true to type plants has been reported by Faisal et al. using TDZ pulse treated nodal explants and the protocol suggested ensures the genetic stability of micropropagated plants. However regeneration rates in phytohormone supplemented medium is more, as expected and as reported by large number of researchers.Another interesting point observed in the in vitro derived plant is the expression of totipotency of excised leaf and stem explants from in vitro plants in PGR free medium and may be used as a model system for study on causes of morphogenesis in vitro [**65**]. Shoot culture in bioreactors is a promising possibility for obtaining higher biomass and bacoside yield, and could be a commercially viable future. Recently, it has been reported that bioactive compounds in *B. monnieri* in vitro cultures can be enhanced by feeding precursors and LED light exposure. Such approaches may be used for shoot cultures in bioreactors in vitro.The medicinal and pharmacological importance of bacopa is increasing daily. *B. monnieri* shows massive potential to relieve various neuropharmacological, inflammation, depressions, and other disorders. For future, however, voluminous research is required to verify its efficacy for various disorders. The ethanolic and methanolic extract of bacopa plays a crucial role in treating human diseases at varying concentrations. Bacoside A is the extensive chemical agent responsible for therapeutic effects identified across various research models. Nevertheless, further studies are required to determine the targeted activity of the bioactive compounds present in the isolated bacoside fraction of BM. The antioxidant activity of bacopa may be useful to treat human pathologies in which free radical production plays a crucial role, which requires further research. Biomedical study of bacopa is still in its formative years, but preliminary results like those depicted in this review can definitely open the floodgates to young researchers.

## VII. CONCLUSION :

The review of the literature indicates evident that a lot of research has been done on the in vitro propagation of Brahmi (B. monnieri) plants, and that mass clonal propagation requires judicial protocol selection in order to be commercialized at a reasonable cost. It has been found that pre-existing meristems, such as nodes and shoot tips derived from both ex vitro and in vitro cultivated plants, can be used to multiply shoots for the clonal growth of B. monnieri. It has been discovered that nodes are a superior explant kind than the other one when it comes to in vitro shoot multiplication. Furthermore, based on the reviewed literature, it can be inferred that compared to similar explants obtained from in vitro plants, internode and leaf explants derived from ex vitro plants exhibit a much higher capacity for micro propagation (155–324 shoots/explant). The results of the study reveal that Bacopa monnieri plants are phytochemically and medicinallyimportant and may be used for human welfare. Therefore, further systematic studies are requiredto explore these plants as an herbal remedies and effective formulations have to be developedusingindigenousmedicinalplants, withproperpharmacologicalexperimentsand clinicaltrials.

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## IX. CONFLICT OF INTEREST :

Authors declare no conflict of interest.

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