



## Comparison of Antioxidant, Phytochemical Profiling of *Bacopa monnieri* (Brahmi)

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### ABSTRACT

The manufacturing of herbal products is now rising quickly worldwide. A variety of healthy natural ingredients have been assessed as treatments for various diseases. The Scrophulariaceae family of perennial creeping plants includes *Bacopa monnieri*, most often referred to as Brahmi, mostly found in areas that are marshy, damp, and humid. *Bacopa monnieri* is a well-known natural remedy that is frequently used as a memory booster all over the world. It is a well-known ayurvedic herb with a lot of benefits. This plant's leaf extract is frequently used in the care of illness. The current review discusses the phytochemical constituent, anti-microbial and anti-oxidant properties of *Bacopa monnieri* Linn. (Brahmi) as well as its pharmacological effects. Numerous disorders, including Alzheimer's, Schizophrenia, Parkinson's, and numerous skin problems, are treated with *Bacopa monnieri*. It exhibits properties that are anti-depressant, anti-anxiety, antioxidant, anti-inflammation, anti-microbial, and anti-fungal. *Bacopa monnieri* Linn. has been used to isolate several compounds; Alkaloids, flavonoids, saponins, and other phytochemical constituents including Bacoside A and Bacoside B.

**Keywords:** *Bacopa monnieri*, Bacoside A & Bacoside B, anti-anxiety, anti-oxidant, anti-inflammation, anti-microbial, anti-fungal properties, etc.

### INTRODUCTION

*Bacopa monnieri* L., often known as Brahmi, is a perennial aquatic herb comprising 146 species worldwide that root at nodes and have branching stems, leaves, and flowers. It has a bitter-sweet taste and is reputed to have cooling properties. It is a plant without any odor. The Central Drug Research Institute, Lucknow, of the Indian government introduced a unique extract of *Bacopa monnieri* in 1996 under the name CDRI08 (Mukherjee et al., 2021). It is

known as the Brahmi plant in Ayurvedic medicine, after the Hindu god Brahma, who created all things. For more than 3,000 years in the Ayurvedic medical system, it has been used to treat different mental illnesses such as anxiety, etc. This plant, which is entirely beneficial for medication, is categorized as the most endangered owing to over-exploitation (Tanveer et al., 2010). Herbal plant products are less expensive and have fewer adverse effects than synthetic pharmaceuticals.

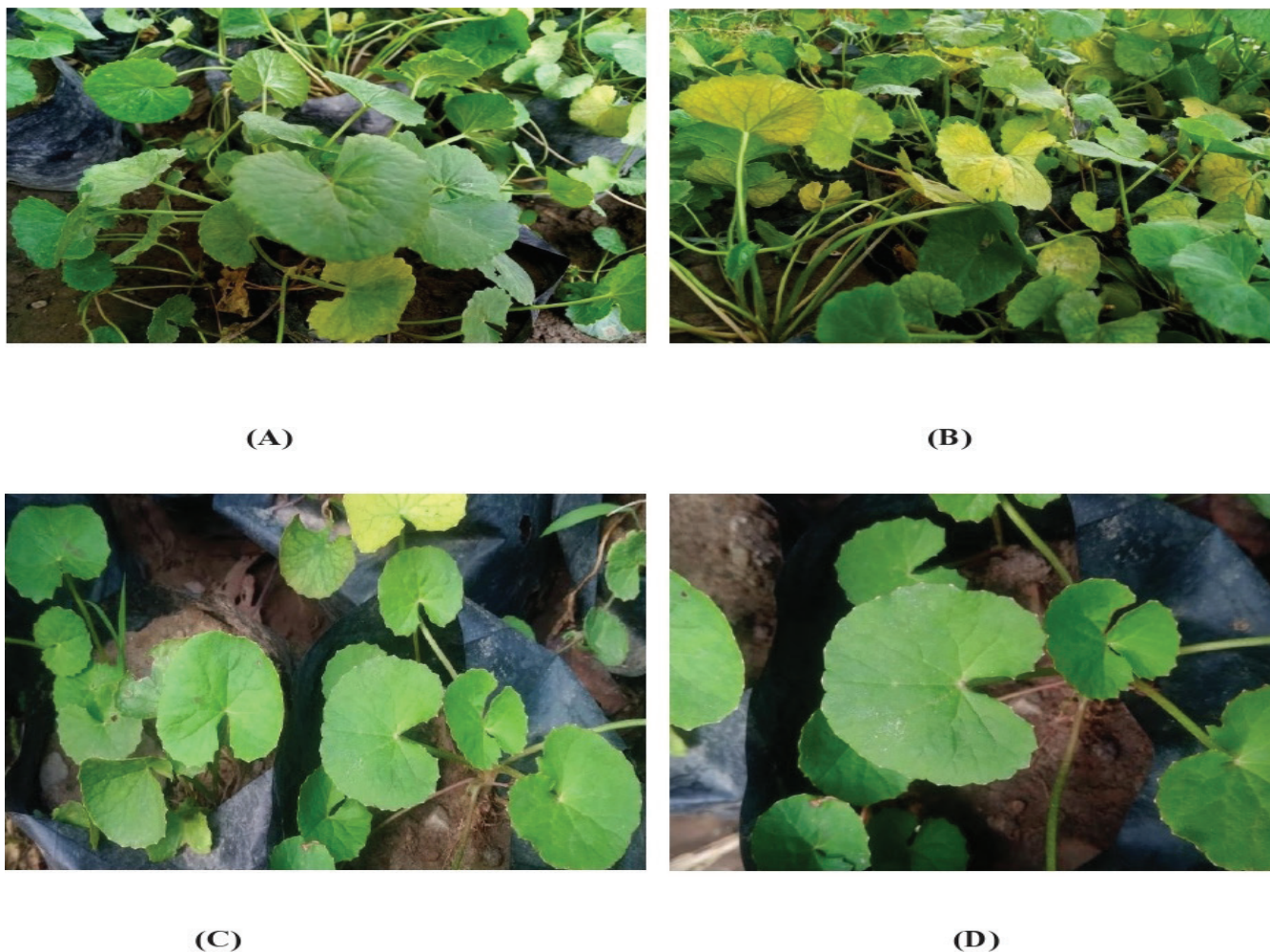


Figure 1: *Bacopa monnieri* plant from different regions of Dehradun. A and B from the Mothrowala region; C and D from Mohkampur region.

**Distribution:** In all tropical and subtropical regions of India, *B. monnieri* may be found growing in marshy places since it prefers a wet habitat along the borders of bodies of water (Swapna et al., 2011). *Bacopa monnieri* may be found in Sri Lanka, India, Nepal, China, Taiwan, Vietnam, Pakistan, and throughout the tropics and subtropics of the world. India as a whole has the plant, but Bengal, Uttarakhand, Uttar Pradesh, Kerala, Tamil Nadu, and Karnataka are where it is most abundant. Important chemical components of *B. monnieri* included a number of alkaloids, including herpestine, nicotine, and brahmin; saponins, including bacosides, betulic acid, and hersaponin; and other substances, including stigmastanol, betasitosterol, and stigmasterol (Tamboli et al., 2018; Figure 1).

**Common name:** Brahmi, thyme-leafed, Indian pennywort water hyssop, Neerbrahmi.

#### Local names of *Bacopa micromonnieria*:

Language	Local Name
Bengali	Brahmisaka
Gujarati	Baam, jalanevari, kadavi luni
Hindi	Jalbuti, jalnim, safed chamani
Manipur	Brahmi sak
Oriya	Prushni parni
Sanskrit	Tiktalonika
Tamil	Pirami, piramiyam, taray
Telugu	Samnrani aku

#### Synonyms of *B. monnieri*:

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*Bacopa monniera* Hayata & Matsum

*Bramia monnieri* (L.) Pennell

*Gratiola monniera* L.

*Herpestes monniera* (L) kunth

*Herpestis fauriei* H.Lev.

*Herpestris monniera*

*Lysimachia monniera* L.

*Moniera cuneifolia* Michx

*Bramia indica*

*Bacopa micromonniera*

### Habit and habitat

Although *B. monnieri* may grow in a broad range of soil types, it prefers damp, somewhat shaded environments. It has a pH range of 6.3 to 8.8, a temperature range of 15 to 40 degrees Celsius, and may be found up to 1300 meters above sea level. Water with a pH range of 5.5 to 7.3 and a hardness range of 142.86 to 535.71 ppm is optimum (Saran et al., 2022). *B. monnieri* grows gregariously and frequently forms dense mats in marshy regions, on the banks of pools, along streams, and in ditches. As per Saran et al. (2022) it is adaptable to brackish water and prefers different types of soil including sand, clay, and loam. A stem that reaches a height of 50 cm, full sunshine for six or more hours each day, and some shade are also required. The need for light was crucial for seed germination, and treatment with gibberellic acid greatly increased seed viability (Mathur and Kumar, 2001).

**Genetics:** *B. monnieri* is  $2n = 64$  (Samaddar et al., 2012).

### Taxonomical classification:

Kingdom	Plantae
Class	Dicotyledones
Order	Scrophulariales
Family	Scrophulariaceae
Genus	<i>Bacopa</i>
Species	<i>monnieri</i>

### Morphological Description:

*Bacopa monnieri*, are herbs that are aquatic or amphibious, prostrate, and semi-succulent, with a creeping stem and climbing branches. Freshwater tidal marshes, riparian regions, streams, pools, and muddy freshwater coastlines are typical habitats. The herb is easily cultivated if enough water is available; it is mostly found at elevations ranging from sea level to 4400 feet; and the plant is utilized as a medicine (Devendra et al., 2018). Sessile, fleshy, oval leaves are placed oppositely on the stem. The small succulent leaves are evergreen. Flowers are pale bluish-purple or white with short pedicels and bracteoles, and blossoming occurs intermittently throughout the year from September to October. Flowers are tiny and antimorphic, with 4-5 petals. Roots are thin, tiny branches

that are wrinkled and off-reddish brown in color. They are longitudinal and around 6-7mm in diameter. The stem is soft, with internodes creeping up to 50 cm and loosely ascending. The seeds are tiny, irregular, longitudinally reticulate, and light reddish brown in color. Fruits occur in the summer and are ovoid, 2-celled, 2-valved capsules that are acute and tipped with style base, odorless, and bitter in taste.

### Phytochemical constituent

The alkaloid, nicotine, herpestine, flavonoids, glycosides, bacosides A and B, triterpenoid, saponins, beta-sitosterol, betulinic acid, D-mannitol, alpha-alanine, aspartic acid, glutamic acid, serine, stigmasterol, etc. are only a some of the phytochemicals that *B. monnieri* contains (Singh, 2012; Bajpai et al., 2021). Roots containing anthocyanins, isoflavonoids, and flavonoids that are part of the phenylpropanoid production pathway (Jeena et al., 2017). The stem of *B. monnieri* included lignified fibers, alkaloids, tannins, saponins, and calcium oxalate, according to the phytochemical analysis (Rautela et al., 2018a, 2020; Khan et al., 2021). In addition to nicotine, bacoside A and B, beta-sitosterol, betulinic acid, D-mannitol, herpestine, and tannin have all been found in leaves.

**Table 1: Plant parts, different extracts, and their biological activities.**

Plant part	Extract	Activity observed	Reference
Whole plant	Ethanollic extract is rich in saponins	Hepatoprotective, Antitumor, Antidiabetic, Anti-inflammatory	Gudipati et al., 2012; Ghosh et al., 2011; Channa et al., 2006.
Whole plant	Alcohol and hexane extract	Antioxidant, Antiepileptic, Anticancerous	Tripathi et al., 1996, Dhanasekaran et al., 2007, Elangovan et al., 1995.
Whole plant	Methanolic extract	Antidepressant, Anti-inflammatory, Antibacterial, Antulcerative	Sairam et al., 2002; Hossain et al., 2014; Khan et al., 2010; Dorababu et al., 2004.
Aerial part	Stigmasterol, phytochemical, bacosine	Anticancer, Antifungal, and Analgesic effect	Ghosh et al., 2011; Chaudhuri et al., 2004; Vohora et al., 1997
Aerial parts	Ethanollic, diethyl acetate, ethyl acetate, and aqueous extract	Antibacterial, Antifungal activity	Sampathkumar et al., 2008.

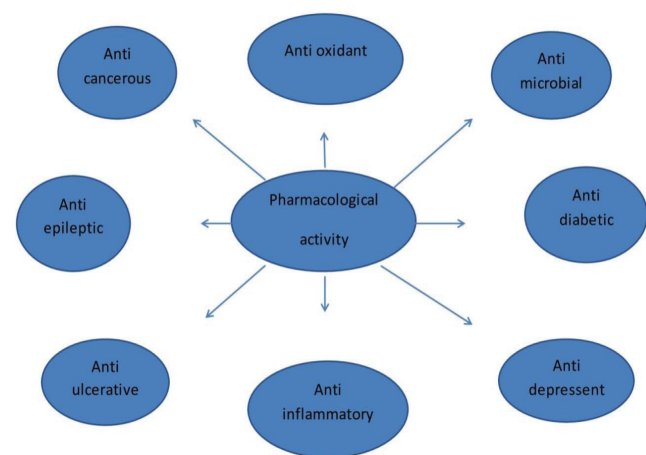
## Reproduction

The *Bacopa monnieri* plant grows hundreds of blue-white flowers throughout the year in India. The self-pollination process is compatible with its reproductive system. The *Apis dorsata*, *Apis florea*, and other species of honey bees are the primary pollinators in India. Despite the *Bacopa monnieri* seed being momentarily dormant, gibberellic acid treatment significantly increased the percentage of germination in the seeds (Mathur and Kumar, 2001).

## In vitro propagation

To standardize the invitro technique of *Bacopa monnieri*, some studies were carried out. Single node explants, cultured on murashige and skoogs healthy leaf segment of the herb were used as explants MS containing various concentrations and cytokinins are an essential part in this process combination of BAP, Kn, NAA and 2,4-D of the two explants leaf showed the best response towards shoot regeneration (Saha et al., 2020; Rautela et al., 2018b).

## Pharmaceutical activities of *Bacopa monnieri*:



**Figure 2: Different Pharmacological properties of *B. monnieri* plant**

## Medicinal property of *Bacopa monnieri*

*B. Monnieri* has been traditionally used as an ethnomedicine to treat anxiety, anger, sleeplessness, nerve discomfort, concentration difficulties, and learning problems. It is a significant herbal medicinal plant that improves memory function and damaged neuron repair. It shows anti-inflammatory, anticancer, antidepressant, anti-aging, and antimicrobial properties (Deokar et al., 2016; Rautela et al., 2018c, 2020; Table 1; Figure 2).

**Leaves:** The major leaf extract has been utilized for the treatment of diseases like ulcers, asthma, and inflammation. The leaves and whole plant are used in skin diseases and mental disorders. Leaf juice is applied to swelling and is a good liniment for rheumatism, this

extract is given to infants suffering from severe bronchitis, improving memory, and treating epilepsy disease (Singh, 2012).

**Stem:** It is used for skin problems, hair infections, and mental disorders.

**Antioxidant:** The Indian herb *Bacopa monnieri* is a dietary antioxidant by regular intake, it reduces the risk of free radicals oxidation. *Bacopa monnieri* is a potential therapeutic antioxidant to reduce oxidative stress and improve cognitive function and also inhibit the toxicity of kidney and morphine induction liver in rats, Diabetes induced caused modulation in SOD activity, it is the first line of antioxidant that generated free radicles SOD oxidant enzyme which involves in physiological defense against free radicles (Kapoor et al., 2009).

The researchers found antioxidant levels improved through bacoside-A. It is found that smoking exposure is improved by oxidative stress and Bacoside-A which protect the brain with the help of antioxidant activity (Rai et al., 2017; Rautela et al., 2018d).

**Anti-cancer effects:** Rats have shown that *Bacopa monnieri* shows an anti-cancer effect against the proliferation and multiplication of cancer cell lines. *Bacopa monnieri* has a compound phenylethanoid that inhibits cancer of the lung, breast, and human colon. Its ethanolic extract is used to observe anticancer activity in different cancer cell lines its proved that the most active extract is the ethanolic extract for human breast cancer (Pandey et al., 2022).

**Reduces the effects of Asthma and Allergy:** Asthma is a complex inflammatory disease that affects about 300 million people around the world, and histamine promotes asthma and allergies. *Bacopa monnieri* extracts are observed to be useful in the reduction of histamine levels and reduce asthma and bronchial dysfunction.

**Gastrointestinal effect and anti-inflammation:** It affects the gastrointestinal system including nausea and vomiting, diarrhea, constipation, etc. *Bacopa monnieri* is protective against gastric ulcers due to its various mucosa offensive and defensive it also reduces inflammation effect by inhibiting prostaglandin synthesis (Saha et al., 2020).

**Anti-microbial activity:** *Bacopa monnieri* contain some ingredients which inhibit the growth of bacteria i.e flavonoids, saponins, and alkaloids they destroy bacteria and also remove bacterial infection. The antimicrobial activity of *Bacopa monnieri* leaves is used to treat microbial infection caused by both gram-negative and positive bacteria. Additionally, it has been reported that the Bacoside A component of *B. monnieri* has more potent antibiotic activity against *S. aureus*, or gram-positive

bacteria, than a typical ciprofloxacin medication. Aqueous extract of *B. monnieri* exhibits no antimicrobial action against any of the bacteria compared to other extracts, with activity shown against *Bacillus subtilis*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* (Joshi et al., 2013; Sharma et al., 2016; Sundriyal et al., 2021).

**Anti-depressant property:** *Bacopa monnieri* counteracts the negative effects of stress and has an adaptogenic impact. The chemical in *bacopa monnieri* aids in maintaining mood balance when used as an anti-depressant.

**Anti-anxiety property:** According to research, *Bacopa monnieri* helps to relieve stress and anxiety by improving mood and lowering cortisol levels, which are directly related to stress levels.

**Anti-arthritic:** Arthritis is a joint inflammation that can affect one or more joints. Osteoarthritis and rheumatoid arthritis are the most frequent types of arthritis. Rheumatoid arthritis affects the majority of people. *B. monnieri* extract has the potential to treat this condition and reduce arthritic symptoms.

#### Anti-diabetic

Diabetes is a condition that also causes high blood pressure. It can be treated with insulin or oral hypoglycemic medications; however, both hypoglycemic and insulin have substantial adverse effects. In order to increase the demand for herbal goods, it has been reported that an ethanolic extract of *B. monnieri* aids in the prevention of diabetes. The ethanolic extract of *B. monnieri* is used to treat this disorder, which is caused by an abnormal metabolic state (Vishnupriya et al., 2017).

**Parkinson's disease:** It is a common CNS condition that impairs mobility and is characterized by the death of dopaminergic neurons in the substantia nigra region and the accumulation of alpha-synuclein in the striatum and adjacent brain regions. The use of *Bacopa* products can reduce inflammation in different brain regions.

**Alzheimer's disease:** Alzheimer's disease is a neurological disorder that impairs both long and short-term memory, mainly in the elderly. The major medicine that is useful for Alzheimer's disease is acetylcholine esters inhibitor for the treatment of mild to moderate Alzheimer's disease, and *Bacopa monnieri* an ayurvedic herb that is most effective.

The plant extract of *Bacopa monnieri* contains acetylcholine esterase inhibitors (Saha et al., 2020). The Indian medicinal plant's great potency heals a variety of complex diseases. *Bacopa monnieri* has a variety of pharmacological effects, including its effect on the central

nervous system. Different phytochemicals contained by *Bacopa monnieri* include alkaloids, saponins, glycosides, and flavonoids, but one phytochemical saponin, bacoside A and B, is particularly essential for various pharmacological actions. This phytochemical aids in the strengthening of memory as well as the improvement of degenerative nerve diseases, which affect many of your body's activities.

**Declaration:** *We also declare that all ethical guidelines have been followed during this work and there is no conflict of interest among authors.*

#### CONCLUSION

In the current review, *B. monnieri* showed a wide range of potential effects in relation to the therapeutic profile and phytochemical constituents of *B. monnieri*. It is clear that this species has a significant number of medical implications (just like Ashwagandha, Mentha, *Nardostachys jatamansi*, *Adhatoda vasica*, *Mucuna puriens*, bubble bush, *Nyctanthes arbour* and other some important medicinal plants) (Gaurav et al., 2015, 2016, 2018, 2019; Bhoora et al., 2015; Pant et al., 2020, 2021, 2022; Sharma et al., 2022; Saini et al., 2021, 2022; Verma et al., 2021; Rawat et al., 2021). The conventional usage of *B. monnieri* and its extracts in ailments including anti-depression, anti-inflammation, anti-cancer, microbial infection, skin and hair problems, and a better immune system has been confirmed in recent pharmacological studies. *Bacopa monnieri* is now being studied in biomedicine and has novel compounds with a wide range of pharmaceutical properties.

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