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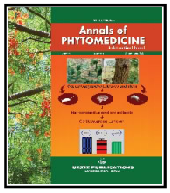

Review Article : Open Access

A comprehensive review on *Bacopa monnieri* (L.) Pennell (Brahmi): Utilization as a functional food ingredient and health-promoting attributes

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Abstract

Bacopa monnieri (L.) Pennell is a traditional medicine that used since ancient times for the treatment of several diseases and in various medical conditions including human memory enhancers. It is utilized as a neuroprotective drug due to its nootropic effects against several neurological diseases. *B. monnieri* also contains bacoside A bioactive compound that is a vital neuroprotective constituent. *B. monnieri* has several functional properties such as antioxidant, antimicrobial, anti-inflammatory, anticancer, antidepressant, *etc.* Commonly, *B. monnieri* is utilized as drug formulations in different Ayurveda treatments. Several researchers fortified *B. monnieri* extract in various food products such as ice-cream, chyavanaprasha, herbal ghee, herbal tea, and beverages. *B. monnieri* extract contains tannins, flavonoids, and glycosides, which add various functional properties to food products. Numerous *Brahmi* incorporated commercial products available in the national as well as international market.

1. Introduction

There are many plants and herbs in Ayurveda that have nootropic effects (*i.e.*, improved lack of concentration, memory, cognitive abilities, and epilepsy), such as Ginko (*Ginko biloba*), mandoo-kaparni (*Centeralla asiatica)*, ashwagandha (*Withania somnifera*), yastimadhu (*Glycirrhiza glabra* Linn.), and *Brahmi* (*Bacopa monnieri*) (Malik *et al.*, 2020). Among these, *Brahmi* is the most studied herb for its health-promoting aspects. The term *Brahmi* has been derived from the word 'Brahma' - creator of the Universe in the Hindu pantheon. The herb *Brahmi* is native to India and Australia (Aguiar and Borowski, 2013), but it is also found in the various parts of the United States and East Asia. *B. monnieri* has a long history of use in the treatment of a variety of ailments, such as epilepsy, anxiety, memory enhancement, lack of concentration, stroke, sedative, mental diseases, *etc.* (Srivastava *et al.*, 2019). The presence of major chemical constituents of *B. monnieri*, such as dammarane-type triterpenoid, are responsible for these functional properties. Saponins, such as bacoside A and bacoside B, are primarily responsible for *Brahmi's* pharmacological activity. Flavonoids, phenylethanoid glycosides, and alkaloids such as brahmine and herpestine are among the other compounds responsible to improve memory and intellect (Kishore *et al.*, 2016). *B. monnieri* is grouped in the madhyarasayana plant, where medha means intellect or retention and rasayana means therapeutic procedure or preparation. Although, traditionally used as a brain tonic due to the active component of *Brahmi*, bacoside. *B.monnieri* has gained much attention due to its nootropic (smart drug) action. Antiasthmatic, anti-inflammatory, anticancer, antioxidant, cardiovascular, and hepatoprotective properties of *B. monnieri* have been studied in *in vitro* and *in vivo* models. Metal ions reduction, free radical scavenging, and lipid peroxidation inhibitory activities, as well as antioxidant enzyme enhancement, are all antioxidant properties of *Brahmi* (Saini *et al.*, 2012). The pharmacological properties of *B. monnieri* have been extensively studied in recent years, and the findings (analgesic, superoxide inhibition, antioxidant, cognitive enhancement) could, at least to an extent, explain and confirm the plant's traditional use. The plant has recently attracted considerable attention in the Western world, and several commercial products claiming adaptogenic and cognitive-enhancing properties are now available (Joshi *et al.*, 2021). For the determination of bacosides in *Brahmi*, several detection techniques such as high-performance liquid chromatography (HPLC) and methods based on UV detection have been developed and successfully implemented for the detection of the functional compound in *Brahmi*. People of all ages have been focusing on foods that have nutraceuticals and functional properties in recent years (Mehrotra, 2021). In India, traditional medicines are used by nearly 80% of the population. Indigenous medicine has net sales that are roughly 1.5 times that of modern medicine (Warrier, 2021). Many commercial products contain the whole *B. monnieri* plant extracts are available in a variety of energy drinks or capsules around the world. Fruit beverages, flavored granules, breakfast cereals, biscuits, memory enhancer tonics, and other functional foods incorporate it. The whole plant

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has also been used to make many homeopathic medicines. *Bacopa* costs about 3-5 USD per kilogram on the market. *Bacopa* extracts are even used in a variety of skincare and cosmetics products, including skin conditioners, cosmetic formulations, and an anti-stress herbal product (Patra *et al.*, 2018). This review contributes to a better understanding that has traced the morphological characteristics, phytochemical constituents, nootropic effects, and other health benefits of *Brahmi* and their application in food product formulations as shown in Figure 1.

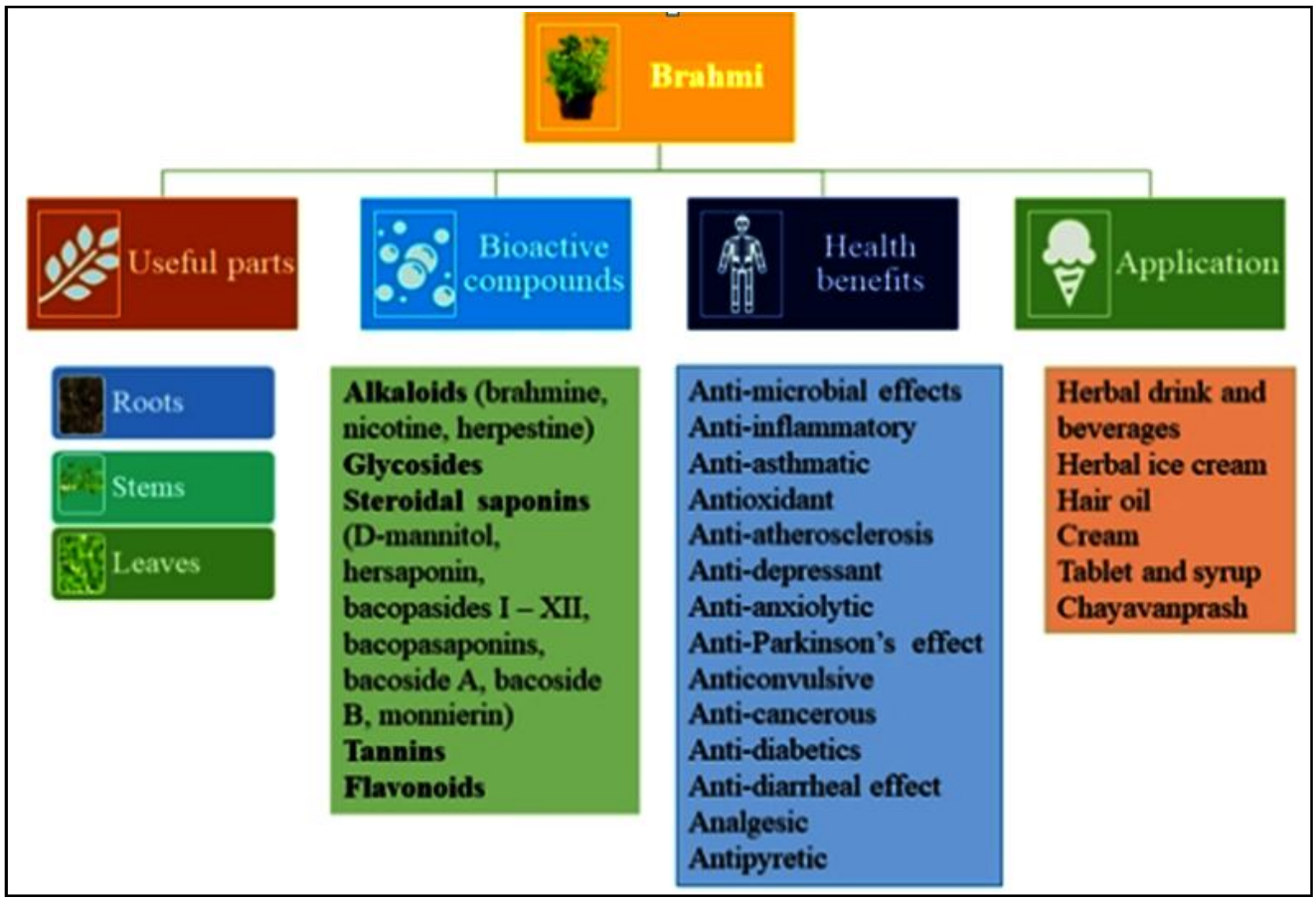

Figure 1: Role of *B. monnieri* as potent ingredients for medicinal purposes as well as functional food development.

2. Morphological characteristics

The herb *B. monnieri*is used as a nutraceutical ingredient in several medical conditions. It is a member of the Scropulariaceae family. It's a small creeping herb with many branches. It thrives in wet soil, shallow water, and marshes in it is natural habitat. Along the stems, small oblong leaves are arranged in pairs. Flowers with five-petaled small tubular petals in a white-purple color. *B. monnieri* can reach a height of 2-3 feet and has 10-35 cm long, slightly bitter branches. The leaves are oval, measuring 1-2 cm long and 3-8 mm wide. The fruits are ovoid, glabrous, and sharp at the apex, with a capsular form up to 5 mm long. For medicinal purposes, the entire plant is used. Water hyssop, Indian pennywort, *Brahmi*, Aaghabini, Petite Bacopa, Jia ma chi xian, Brahmibuti, Bakopa, and Adhabirni all are popular names for the *B. monnieri* (Trivedi Manisha *et al.*, 2011).

3. Phytochemical constituents of *B. monnieri*

The *Brahmi* extract contained triterpenoids, saponins, alkaloids, glycosides, and alcohols. Alkaloids found in *Brahmi* extract include "brahmine," nicotine, herpestine (Singh, 2012; Pant *et al.*, 2015), and glycosides (Tothiam *et al.*, 2011). A major bioactive component of *Brahmi* is the dammarane type triterpenoids saponins such as bacoside A [3-(α-L-arabinopyronsyl)-O-β-D-glucopyronaside,20-dihydraoxy-16-keto-dammar-24-ene]. Further, several researchers reported that the presence of the triterpenoid saponin 3-β-[O-β-d-glucopyronosyl (1-3)-O-[α-L-arabinofuranosyl (1-2)]-O-β-d-glucopyranosyl) oxy], termed bacoside A3. Chemicals found in *Brahmi* extract's glycoside component include pseudojujubogenin, which is chemically identified as 3-O-[α-1-arabinofuranosyl (1–2) β-d-glucopyranosyl]. *Brahmi* methanolic extract yielded two pseudojujubogenin glycosides known as 3-O-α-l-arabinofuranosyl-1(1–2)-[6-O-sulphonyl-β-D-glucopyranosil-(1–3)]-α-l-arabinopyranosylpseudojujubogenin and 3-O-α-l-arebinofuranosyl-(1–2)-[β-D-glucopyronosil-1(1–3)] β-d-glucopyranosyl pseudo-jujubogenin. The ethanolic extract of *Brahmi* yielded a novel saponin named bacopa saponin G, which was chemically identified as 3-O-[α-1-arabinofuranosyl-1(1–2)]-α-L-arabino-pyrosyljujubo genin. A phenylethanoid glycoside, 3,4-dihydroxyphenylethyl alcohol (2-O-ferulolyl)-β-d-glucopyronoside and phenylethyl alcohol [5-O-p-hyroxy-benzoyl-β-d-apifuranosyl-(1–2)-β-d-glucopyranoside] "Bacoside A" and "Bacoside B" are the main components and both

possess hemolytic activity. Additionally, *Brahmi's* neuroprotective properties are attributed to these compounds. Bacoside A is a saponin mixture that includes bacoside A3, bacopaside, jujubogenin, and bacoposaponin C. The mevalonate (MVA) and methyl-D-erythritol-4-phosphate (MEP) pathways have been used to synthesize bacoside (Dubey and Chinnathambi, 2019).

4. Nutraceutical properties and health benefits of *Brahmi*

4.1 Antioxidant property

Antioxidants can reduce oxidative stress in the body by scavenging reactive oxygen species and preventing or repairing the damaged tissues of the body. Under oxidative stress, antioxidant enzymes such as glutathione peroxidase, superoxide dismutase, glutathione reductase, and catalase provide the first line of defense against free radical damage. Non-enzymatic antioxidants such as vitamin E (á -tocopherol), vitamin C (ascorbic acid), and glutathione are phenolic compounds that protect by converting oxidants to non-radical end products or transporting radicals to areas where their effects are less harmful (Simpson *et al.,* 2015). The use of *B. monnieri* leaf regularly may help with the treatment of neurological disorders related to free radical damage. *B. monnieri* has been found to have high antioxidant properties shown in (Table 1), which were tested using a crude methanolic extract of the plant's aerial parts, measuring free radical scavenging activity, and determining ascorbic acid, tannin, and phenols (Meena *et al.,* 2012).

4.2 Antimicrobial effects

Active compounds in *Brahmi*, such as flavonoids, saponins, and alkaloids, aid in the ruination of bacteria. According to Azad *et al.* (2012), 1 mg/ml of ether extract produced from *B. monnieri* had antimicrobial activity against *Salmonella typhi*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Vibrio cholerae* and *Candida albicans*. The disk diffusion method revealed that the chemical constituent present in *B. monnieri* had antibacterial effects against gram-negative and gram-positive bacteria due to ethyl acetate and methanol (Khan *et al.,* 2010).

4.3 Anti-inflammatory activity

In mice and rats with carrageenan-induced paw edoema, the ethanolic extract of *Brahmi* was found to have an anti-inflammatory effect as shown in Table 1. Triterpenoids and bacosides found in *Brahmi* extracts have been shown to inhibit the activities of 5-lipoxygenase (5-LOX), 15-LOX, and cyclooxygenase-2 (COX-2). Hossain *et al.* (2014) found that a 400 mg/kg body weight dose of methanolic *B. monnieri* extract has significant anti-inflammatory activity.

4.4 Anticancer activity

Bacopaside E and bacopaside VII, which were isolated from the n-BuOH fraction of *B. monnieri*, had a potential antitumor effect (Peng *et al.,* 2010). The whole plant, including the ethanolic extract of *B. monnieri*, has a positive effect on a human breast cancer cell line. The presence of saponins and flavonoids in MDA-MB-468 may be related. Ghosh *et al.* (2011a) investigated the antitumor activity of stigmasterol, which was isolated from the aerial parts of the herb *B. monnieri*, against Ehrlich ascites carcinoma in Swiss albino mice.

4.5 Antidiabetics property

Some indigenous peoples in Orissa, India, use a decoction made from the aerial parts of the herb *Brahmi* to treat diabetes mellitus. Bacosine, a triterpene responsible for the increase in glycogen content in diabetic rats, was found in the ethanolic extract of *B.monnieri*, according to Ghosh *et al.* (2011b). In alloxan-induced diabetic rats, the ethanolic extract increased peripheral glucose utilization *in vitro* in the diaphragm of diabetic rats, suggesting that it may have insulin-like activity (Rai *et al.,* 2017).

4.6 Gastrointestinal effects

It has been proven that *B. monnieri* can effectively protect against gastrointestinal problems. Castor oil-induced diarrhea in mice was treated with an ethanolic extract made from the whole plant of *Brahmi* at a dose of 500 mg/kg. It reduced the frequency of defecation while improving the mean latent period (Ajalus *et al.,* 2012). The antiulcergenic activity of fresh *Brahmi* leaf juice and extracts is significant. Gastric ulcers are protected by it. The ulcer-protective effect could be due to its effect on intestinal mucosa counter attacking factors and it was discovered that the extract of *Brahmi* significantly healed penetrating ulcers caused by acetic acid, strengthened the mucosal barrier, and reduced mucosal exfoliation (Deo *et al.,* 2013).

4.7 Analgesic effects

B. monnieri was suggested as adjuvant therapy for neuropathic pain. Further more, *Brahmi* altered opioid tolerance and demonstrated morphine-like effects without inducing tolerance. According to the findings, it was observed that *Brahmi* inhibits pro-inflammatory mediators like TNF-α and IL-6 while increasing the expression of chemokines like MCP-1, COX-2, and iNOS in the brain. Adult zebrafish were given *Brahmi* at concentrations of 0.625, 1.25, and 2.5 mg/ml, and glutamate was injected intramuscularly after half an hour. When compared to control group animals, *Brahmi* (1.25 and 2.5 mg/ml) and indomethacin significantly reduced the glutamate-induced increase in the number of line crossings. In addition, indomethacin and *Brahmi* (1.25 and 2.5 mg/ml) significantly reduced the glutamate-induced increase in cytosolic calcium. In the zebrafish brain, there was also a significant improvement in mitochondrial function, integrity, and bioenergetics in terms of respiratory control rate. Furthermore, glutamate-induced mitochondria-dependent apoptosis in the zebrafish brain was significantly reduced by *Brahmi* (1.25 and 2.5 mg/ml) and indomethacin. As a result, *Brahmi* could also be a promising alternative drug candidate for pain management (Sharma *et al.,* 2022).

4.8 Nootropic effects

The term 'nootropic' comes from the Greek words noos, which means mind, and tropein, which means to monitor or turn. Nootropics are so-called "smart drugs" or natural supplements that improve the function of brain cells. It is a non-toxic neuroprotective compound used to treat Alzheimer's disease (AD) and improve memory and cognitive function (Chaudhari *et al.,* 2017; Colucci *et al.,* 2012). Nootropics have several functions, including increasing acetylcholine levels in the brain, supplying neurochemicals (such as neurotransmitters, enzymes, and hormones) to the brain, and increasing oxygen supply to the brain (Suliman *et al.,* 2016; Crespo-Bujosa *et al.,* 2019).

4.9 Alzheimer's disease (AD) treatment

Alzheimer's disease (AD) is a neurodegenerative disease marked by amyloid plaques. Memory loss, disorientation, cognitive decline, and increased confusion are all symptoms of Alzheimer's disease. In a nutshell, Alzheimer's disease is a progressive disease that impairs memory and other critical mental functions. There is currently no cure for Alzheimer's disease, as well is a lack of treatments and pharmaceuticals. Because medications for Alzheimer's disease are ineffective, researchers are looking into alternative therapies like nutraceuticals. Because of its antioxidant, anti-inflammatory, and amyloid-beta (A) aggregation inhibitor properties, *B. monnieri* produces polyphenolic compounds known as bacosides, which act as a therapeutic agent. Bacosides can improve the efficiency of signal transmission along nerve fibers, resulting in improved memory and cognition (Halder *et al.*, 2021) as shown in Table 1.

4.10 Memory enhancer

Long-term consumption of *Brahmi* has been shown to improve memory, concentration, and attention span studies. *Brahmi* aids in the reduction of norepinephrine and dopamine levels in the brain, resulting in improved cognition. *Brahmi* is used as a tonic for school-aged children to help them remember things. It also helps with age-related memory loss because it contains antioxidants, which may reduce the damage caused by free radicals, allowing older people to learn and retain more information. The neuroprotective properties of *B. monnieri* at 100 mg/kg body weight for 180 days on memory deficits and biochemical changes in the ATPase system of Alzheimer's disease (AD) induced mice were investigated by Kunte and Kuna (2013). *B. monnieri* could revert all the constituents of the ATPase system to normal levels in AD-induced mice, which revealed a positive result on body weight, memory concentration, and learning skills. As a result, it was determined that *B. monnieri* has a positive effect and can effectively prevent learning and memory deficits as well as maintain ion gradients across biological membranes, providing significant neuroprotection against Alzheimer's disease.

4.11 Anti-depressant and antianxiolytic effects

The active constituents of *B. monnieri* increase serotonin levels in the brain when the *Brahmi* leaf is taken, which relieves anxiety, nervousness, and depression and allows the mind to relax. The methanolic extract of *B. monnieri* at doses of 100 and 200 mg/kg was found to have potential antidepressant effects and increased locomotion (Mannan *et al.*, 2015), and doses of 80 mg/kg of *Brahmi* leaf extract produced a significant response of anxiolytic effects (Chatterjee *et al.*, 2010).

4.12 Anti-Parkinson's effects

Parkinson's disease is a neurodegenerative disorder in which the substantial nigra produces dopamine and alpha-synuclein protein. Jadiya *et al.* (2011) investigated the effects of *B. monnieri* on two different strains of caenorhabditis elegans, a transgenic model of human Parkinson's disease. The findings revealed that *Brahmi* kills dopamine-producing cells and reduces alpha-synuclein aggregation clusters. As a result, *B. monnieri* prevents dopaminergic neurodegeneration in nematodes and restores lipid content, proving that it is an anti-Parkinson agent.

4.13 Anticonvulsive property

Animal research and Ayurvedic medicine have shown that *B. monnieri* has anticonvulsant activity only at high doses for long periods. The bacoside in *Brahmi* promotes acetylcholine, which activates GABA (gamma-amino butyric acid), which balances the chemicals in the brain that control seizure activity. Seizures are caused by abnormal electrical activity in the brain, which can lead to unconsciousness. *Brahmi* aids in the prevention of seizures and the effective maintenance of brain function. Mathew *et al.* (2012) investigated temporal lobe epilepsy, a common epileptic syndrome. The effect of *B. monnieri* on GABA binding and gene expression was reported in the cerebral cortex region of epileptic rats and was studied the bacoside-A as a therapeutic effect.

Table 1: Health-promoting properties of *Brahmi* (*B. monnieri*) extract and formulations

Health conditions	Treatment/Doses	Effects	References
Anxiety and depression	Methanolic extract of *Brahmi* (100 and 200 mg/kg dose)	Antidepressant effects and increased locomotion.	Mannan *et al.* (2015) Chatterjee *et al.* (2010)
	80 mg/kg dose of *Brahmi* leaf extract	Produced significant response of anxiolytic effects.	
Cognitive effects	Standardized CDRI-08; Keen Mind (300 mg/day dose)	Shows enhancement of cognition in aging.	Morgan and Stevens, (2010)
	Capsule of 300 mg for 12 weeks	Improved memory acquisition and retention in elderly people. It also, improved cognitive performance, attention, and memory function.	Peth-Nui *et al.* (2012)
Scopolamine induced cognitive impairments in rat brain	*B. monnieri* extract (10, 20 and 40 mg/kg dose)	Enhanced cognition and neuro-modulator tendency by controlled expression of acetylcholine esterase (AChE) activity, brain-derived neurotrophic factor (BDNF), muscarinic M1 receptor (MUS-1), and cAMP response element-binding protein (CREB), and also by changing the levels of neurotransmitters in the hippo-campus of the rat brain.	Pandareesh *et al.* (2015)

Aluminum induced oxidative stress and hippocampus damage in Rats	*B. monnieri* extract (40 mg/kg Dose)	Structural derangement in the hippocampus by aluminum is directly proportionated with increased lipid peroxidation by *B. monnieri* extract.	Tripathi *et al.* (2011) Nannepaga*et al.* (2014)
Renal oxide- lipidemic stress in hypercholesterolemia rats	Alcoholic (ethanol) extract of *Bacopa monniera* (40 mg/kg dose) *B. monniera* extract (320 mg and 640 mg dose)	Act as a renoprotective agent by abating the renal oxido-lipidemic stress through NOS level regulation and thus protects the nephrons in hypercholesterolemia rats. Supplementation of *Brahmi* reduced stress and alleviated mood	Kamesh and Sumathi (2014) Benson *et al.* (2014) Kamkaew *et al.* (2013)
Cerebral blood flow	Administration of *Brahmi* leaf extracts orally for 8 weeks	Cerebral blood flow in wistar mice was tested using a stereotactic laser doppler probe placed over bregma. basilar artery showed antiChE dependent vasodilation on the administration of *Brahmi* leaf extract, increased cerebral blood flow by 25%.	
Inflammation	Dose of 400 mg/kg methanolic extract of *Brahmi*	Experimented through carrageenan and histamine-induced edema test on rats, 400 mg/kg of *Brahmi* extract significantly showed anti-inflammatory activity.	Hossain *et al.* (2014)
Cold stress-induced neurodegeneration in rats	40 mg/kg dose of *Brahmi* extract	The extract produced a neuro-protective effect in cold stress-induced hippocampal neurodegene-ration of rats when administered orally.	Kumar *et al.* (2015)
Ischemia-reperfusion injury in rat	Orally fed *B. monnieri* (75 mg/kg dose, for three weeks	It restored the antioxidant network of the myocardium and reduced myocardial apoptosis, caspase 3, bax protein expression.	Mohanty *et al.* (2010)
Antimicrobial effect	Ether extract of *Brahmi* (1 mg/kg dose)	It effectively showed antimicrobial activity against bacteria and fungus.	Azad *et al.* (2012)
Anticonvulsive effects	*Brahmi* extract (50 and 55 mg/kg dose)	*Brahmi* extract has an anti-convulsive effect in rats with an action mechanism akin to benzodiazepines (GABA agonists)	Kaushik *et al.* (2009)
Anticancer effects	Methanol extract *B. monniera* (50 µmol/kg dose)	At a concentration of 50 µmol/L, it strongly inhibited human breast cancer cell line MDA-MB-231 adhesion, migration, and Matrigel invasion *in vitro*.	Peng *et al.* (2010)
Morphine induced liver and kidney toxicity in rats	For 21 days, *Bacopa monniera* extract (40 mg/kg dose) was fed orally once a day 2 hours before morphine injection	In terms of serum glutamate oxaloacetate transaminase, alkaline phosphatase, lactate dehydrogenases, and gamma-glutamyl transferase activities, as well as urea, creatinine, and uric acid levels.	Sumathi and Niranjali (2009)
Cognitive performance, anxiety, and depression in the elderly	*Bacopa monnieri* extract (300 mg/ day for 12 weeks)	The Bacopa group's Center for Epidemiologic Studies Depression scale (CESD)-10 depression ratings, combined state plus trait anxiety scores, and heart rate all reduced with time, while the placebo group's increased.	Calabrese *et al.* (2008)

5. Application of *Brahmi* in functional innovative food products development

Brahmi is now used to make herbal teas and beverages, ice cream, syrup, tablets, hair oil, cream, and chyavanaprasha, among other things (Devendra *et al*., 2018). The presence of several bioactive compounds and their health-beneficial effects have increased the popularity of *Brahmi* as an ingredient in product formulation as shown in Table 2. The food industry is compelled to include natural antioxidants in food products to impart oxidative stability because consumers prefer natural or organic foods. *B. monnieri*, as herbal extract, is a potent natural antioxidant that can be used in a variety of food products (Warrier, 2021). The extract improves not only the sensory quality but also the shelf life of the product (Tanwar *et al.,* 2017).

Table 2: Application of *Brahmi* in functional innovative food products development

Food product	Constituent	Claims	References
Herbal whey beverage	Addition of *Bacopa monnieri* extract (BME) @ 1.5- 3% to whey	The optimized product contains 3% *Bacopa monnieri*, 16% sucrose, and 0.4% calcium gluconate of the whey based on the sensory evaluation with an overall acceptability score of 7.10 ± 0.06 (3%), 8.65 ± 0.02 (16% Sucrose), and 0.95 ± 0.02 (0.4% calcium gluconate).	Kumar *et al.* (2018)
Cereal bars	Puffed rice (50-100 g) + chocolate (200 g) + *Brahmi* and noni herbal extract (2-4 g)	Antioxidant activity of the bars is found to be high, formulated cereal bars are found to be rich in phenolic content, and flavonoids, and also they have a better shelf life, antioxidant activity of the bars is found to be high.	Pathak *et al.* (2018)
Chicken nuggets	Chicken nuggets incorporated with 1, 2, and 3 per cent *Bacopa monnieri* extracts	Chicken nuggets prepared with 2 per cent of *Bacopa monnieri* were adjudged as the best among all based on sensory attributes. Extracts of *Bacopa monnieri*-incorporated nuggets were safe for consumption until 21 days of refrigerated storage (4 ± °C).	Tanwar *et al.* (2017)
Whey-based herbal beverages	Whey (65%), sugar (11%), *Brahmi* extract (3%)	Nutritionally rich whey-based herbal drinks can be recommended to all groups of people.	Kanchana *et al.* (2021)
Herbal ice cream	Calcium gluconate (CG) and BME levels were fixed as 50-250 mg/100 ml and 10-50 mg/100 ml of ice cream mix	Optimum levels of CG and BME are 217.34 mg/100 ml and 10 mg/100 ml for the preparation of experimental ice cream. Calcium-fortified ice cream prepared.	Baig *et al.* (2019)
Herbal buffalo ghee	Buffalo ghee by using flaxseed oil at different levels @5 per cent, @10 per cent, and @ 15 per cent and *Brahmi* leaves at different levels @5 per cent, @10 per cent, @15 per cent, and @20 per cent of the content	The most acceptable quality buffalo ghee was prepared by using 10 per cent flaxseed oil and 15 per cent *Brahmi* leaves.	Kumari and Hossain (2020)
Health drink mix	Whole wheat flour (50 g) + finger millet flour(25 g) + Green gram flour powder (25 g) + 3-5% *Brahmi* leaf powder + jaggary 17g + milk 2l + water 500 ml + cardamom (2 pinch)	5% incorporation of *Brahmi* leaf powder, the secured maximum score in overall acceptability. good for health fresh leaves may be hard to consume, as they are bitter. So that drink mix can be a better option for all aged people.	Amaravathi *et al.* (2020)
***Brahmi* leaf-based puttu mix**	Whole wheat flour (50 g) + Finger millet flour(40 g) + Green gram flour powder (10 g) + Vallarai and nir *Brahmi* powder (%) - 4-6 + Sugar (30 g) + Coconut (30 g)	4% incorporation of *Brahmi* leaf powder, the secured maximum score in overall acceptability.	Amaravathi *et al.* (2020)
Nutri balls	Wheat flour (40 g) + Finger millet flour (20 g) + Roasted bengal gram flour (25 g) + Green gram flour (15 g) + Nir *Brahmi* and vallarai green leaf powder (%) - 2- 3	2% incorporation of *Brahmi* leaf powder, the secured maximum score in overall acceptability.	Amaravathi *et al.* (2020)
Soup mix	Carrot powder, beans powder, tomato powder, onion powder, peas, ginger garlic powder with other ingredients (Corn flour, salt, citric acid, pepper powder, sugar + Dried *Brahmi* leaf powder (4-6%)	4% incorporation of *Brahmi* leaf powder, the secured maximum score in overall acceptability.	Amaravathi *et al.*, (2020)

Table 3: Commercially available *Brahmi* formulations and *Brahmi* fortified food products in the Indian market

Product	Brand/description	Manufacturing company	Location
Dried powder	ORGHERB	Ayush Life Elements	Madhya Pradesh, India
***Brahmi* pearls**	Memory booster medicine	Kerala Ayurveda Ltd. Athani Post, Aluva, Ernakulam District,	Kerala India
Usda organic *Brahmi* powder	Mi nature	Mi nature	India
***Brahmi* powder**	Your brand	Global Hindustan Hills	India
Tablet	-	Himalaya Wellness	Karnataka India
***Brahmi* chyavanaprasha**	Planet ayurveda	PLANET AYURVEDA, Plot No. 627 Sec. 82 JLPL Industrial Area, Mohali	India
Herbal tea	Sorich organics	SOPL Retai	India
Vallarai *Brahmi* syrup	GJ	GJ Global Herbs	India
Herb	-	Amritanjali Ayurved Pvt. Ltd., Udaipur, Rajasthan	Rajasthan, India
***Brahmi* oil**	Kanta	Kanta Enterprises Private Limited, New Delhi	New Delhi, India
Vedic line neem *Brahmi* cream	Vedic line	Kapco International Ltd.	India

6. Current status of *Brahmi* application is related to products available in market

Lots of manufacturing companies are involved in *Brahmi*'s added product formulationdue to its demand in the market as shown in Table 3.

7. Conclusion

Brahmi medicinal plant used in drug formulations since ancient times and its functional and therapeutic properties are clinically proven in the various *in vitro* and *in vivo* models. Memory loss, depression, cognition, inflammation, Alzheimer's disease, Parkinson's disease, and other disorders are all treated with *Brahmi* (*B. monnieri*), a traditional plant. Numerous commercial food products are fortified with *Brahmi* and available across the country. The various problem comes during the incorporation of the herb into food products. *Brahmi* has a typical bitter and pungent aroma and it affects the sensory quality of food products. There is a need for technical intervention for the incorporation of *Brahmi* in food products such as the utilization of nanotechnology in product development.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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