



REVIEW ARTICLE

Innovative approaches for incorporating brahmi (*Bacopa monnieri*) in postharvest food processing

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ABSTRACT

The ayurvedic herbs have the greatest potential for benefiting the population, particularly those who live in countries where poverty and bad health are prevalent. Brahmi (*Bacopa monnieri*) is a well proven herb of many medicinal properties. All the parts of the plant can be used as medicine. Brahmi leaves are a powerhouse of valuable alkaloids and triterpene saponins that can stimulate brain chemicals for sharper thinking, memory and learning. Herb contained alkaloids of brahmine and herpestine. Brahmi leaf is one of the best examples of an ayurvedic plant, as it has all of the vital nutrients, antioxidants and phytochemical substances in a single leaf. Alkaloids, flavonoids, glycosides and saponins are only a few of the many phytochemicals found in bacopa plants. Bacosides, bacopasides and bacopa saponins are the other significant components of this plant, and these or what give it its therapeutic properties. Dried foods play an essential role in the food supply chain in today's market. The development and use of brahmi in functional meals will benefit not only the general public's nutritional status, but also people suffering from degenerative diseases. Brahmi can be consumed as a vegetable and the leaf powder can be dried in a dryer and stored for several months without refrigeration.

Keywords: *Bacopa monnieri*, functional foods, saponin, phytochemicals, antioxidants

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INTRODUCTION

Herbal products have been increasingly popular in recent years, both in the developed world and in developing ones. Brahmi is an essential medicinal herb that has long been utilised for therapeutic purposes in the East and is gaining popularity in the West.

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Brahmi is a Sanskrit word that means "Lord Brahma" or "Brahman". Lord Brahma is the Hindu name for the cosmic awareness, and Brahman is the divinity responsible for all of the world's creative forces (Smitha et al., 2021).

The health benefits of phytochemicals found in plant meals have recently piqued scientists' curiosity. Plants produce a huge number of secondary metabolites known as phytochemicals. Because of a long history of consumption, most natural phytochemicals found in plant foods are thought to be safe. Today, there is a lot of interest in medications that come from plants. Medicinal plants have the ability to treat a variety of ailments. Traditional medicine practitioners outnumber allopathic practitioners in rural regions, according to studies. Around 80% of people in rural parts of developing and underdeveloped countries still rely on medicinal herbs (Dubey and Chinnathambi, 2019).

Total medicinal and aromatic plants production in India is estimated as 7,61,180 million tonnes with the area of 6,84,780 ha during the year 2019-20. Total medicinal and aromatic plants production in Rajasthan is estimated as 3,02,110 million tonnes with the area of 4,38,010 ha during the year 2019-20. India is the world's second-largest exporter of medicinal plants. India is second only to China in this ranking, with 6,600 medicinal plants, and the two countries combined produce over 70% of the world's herbal medicine need. Rajasthan, with 56 percent of the total area under medicinal and aromatic crops, is the most populous state, followed by Uttar Pradesh (25 per cent). In terms of production, Madhya Pradesh comes in front with 44% while Rajasthan comes in second with 19% (Chowti et al., 2018).

Herbal processing refers to the techniques for preparing herbal resources and herbal preparations, as well as the manufacture of final herbal products, all with the purpose of ensuring the quality of herbal medicines. Herbal materials and herbal preparations may be used as starting materials or intermediates in the production of completed herbal products, or as herbal dosage forms for therapeutic uses, depending on the intended usage. Inspection and sorting, basic processing and drying are all part of the post-harvest processing of herbs. The specifics of herbal processing may differ from one herb to the next. Before being dried, certain techniques simply require a few simple steps of primary processing, such as cleaning, primary cutting and sectioning (WHO, 2018).

The ayurvedic plants represent a vast collection of organic compounds, many of which have been employed for therapeutic purposes and could serve as a guide for drug development. Chemical compounds found in ayurvedic herbs aid in the treatment of a variety of mental problems. The ayurvedic herbs have the greatest potential for benefiting the population, particularly those who live in countries where poverty and bad health are prevalent (Merina et al., 2012).

The brahmi, which have a high concentration of secondary metabolites that provide active substances that stimulate cell upgrading, improve physical and mental wellness. Brahmi leaf is one of the best examples of an ayurvedic plant, as it has all of the vital nutrients, antioxidants and phytochemical substances in a single leaf. Brahmi leaf has recently attracted a lot of attention, due to its numerous uses and benefits for ADHD (Attention Deficit Hyperactivity Disorder) and other health conditions. Brahmi can be consumed as a vegetable and the leaf powder can be dried in a cabinet dryer and stored for several months without refrigeration. The dried brahmi leaf is ground into a powder that may be added to any dish to assist boost the nutritional value of the cuisine (Amaravathi et al., 2020).

Aublet initially defined the genus *Bacopa* in 1775. He named the species *Bacopa* after the specimen and the term *Bacopa* was derived from the Latin name that these plants were known by among the indigenous Caribe (American Indian) people of French Guiana at that time (Sudhakaran, 2020). The scientific classification of brahmi has present in the following Table 1:

Table 1: The scientific classification of brahmi (*Bacopa monnieri*)

Kingdom	Plantae
Division	Anthophyta
Class	Dicotyledoneae
Order	Scrophulariales
Family	<i>Scrophulariaceae</i>
Genus	<i>Bacopa</i>
Species	<i>monniera</i>

Bacopa monnieri is containing a number of compounds that give it its therapeutic as well as medicinal effects. These are some of them are Brahmin, Saponin, Beta-sitosterol, Betulinic acid, Sigmasterol and D-mannitol. *Bacopa monnieri* is renowned as a brain-boosting herb because of these phytochemicals, which increase brain health. Phytochemicals found in brahmi are nicotine, desaponin glycosides and herpestine. This herb is utilised as an anti-diabetic, liver-enhancer, anti-ulcerogenic, anti-pyretic (treats fever), carminative, analgesic, anti-asthmatic, anti-bacterial and many other things because it has so many beneficial components (Anon, 2016).

The advantage of incorporating brahmi in daily food routine

Brahmi is a well-known herb with a wide range of therapeutic qualities. All of the plant's parts can be utilised as medicine. The usage of herbal products has risen dramatically in recent years in both the Western world and industrialised countries, owing to their numerous health benefits. There are many food products on the Indian market that use brahmi as a functional food ingredient. The usage of herbs such as brahmi as a functional food ingredient will revolutionise the functional food business since it has enormous potential to provide customers with better health advantages. Brahmi is a well proven herb of many medicinal properties. All the parts of the plant can be used as medicine. In recent times, the use of herbal products has increased tremendously in the western world as well as in developed countries due to its tremendous health benefits. There are numerous of food products available in market of India which contains brahmi as functional food ingredients. With the use of herbs like brahmi as a functional food ingredient will bring revolution in the functional food market as it has immense potential to provide greater health benefits to the consumers (Devendra et al., 2018).

**Fig 1. Brahmi (*Bacopa monnieri*)**

Brahmi leaves are a powerhouse of valuable alkaloids and triterpene saponins that can stimulate brain chemicals for sharper thinking, memory and learning. It can be tossed in salad, dry and powder the leaves to sprinkle in curries and chutneys. As per certified Ayurvedic, the decoction of brahmi powder in boiled water can be ingested at a dose of 25 to 50 mL per day for adults. For infants and children, brahmi can be given in very small doses, in the form of brahmi ghrita, mixed with honey, ghee and some water, which assists in bolstering brain power and immunity in kids (Deo and Reddy, 2015). Brahmi is believed to be the key revitalising herb for nerve and brain cells. (Ashalatha and Shenoy, 2016)

Saha et al. (2020) investigated in vitro propagation, phytochemical and neuropharmacological profiles of *Bacopa monnieri*. In India's ancient ayurveda system, *Bacopa monnieri* has long been utilised as a reputable medication. This therapeutic herb contains significant phytopharmaceuticals. The bioactive components of *Bacopa monnieri* have been the subject of intense research in recent years, both for their potential to improve memory and for their wide range of additional beneficial effects. It has a variety of pharmaceutical properties, including antioxidant, gastrointestinal, endocrine, antibacterial and anti-inflammatory ones. Additionally, neurological and neuropsychiatric conditions have been treated using the plant.

Brahmi consumed as a potent 'brain tonic' in ancient medical texts, and various Ayurvedic remedies like Brahmi ghrita, Brahmi rasayana, Brahmi vati, and Saraswata ghrita utilize it extensively. Over the past eighty years, exhaustive phytochemical investigations have led to the identification of 98 secondary metabolites in *B. monnieri*, including dammarane type triterpenoid saponins, pentacyclic triterpenes, phenylethyl glycosides, phenylpropanoid glycosides, cucurbitacins, steroids, flavonoids, alkaloids, and other miscellaneous compounds. These compounds collectively contribute to the plant's medicinal properties and efficacy in traditional Ayurvedic medicine (Kunjumon et al., 2022).

Potential Health benefits of brahmi for human body:

Brahmi includes a variety of chemicals that give it its therapeutic characteristics which include: Brahmin, saponins, beta-sitosterol, stigmasterol, betulinic acid and mannitol. Each of these substances has a distinct pharmacological profile that aids in illness therapy and management. Nicotine, desaponin glycosides, and herpestine are among the phytochemicals found in it. These phytochemicals are compounds that help to improve brain health, which is why it is referred to as a brain boosting herb (Mathur et al., 2016).

In the last several years, Brahmi consumption has exploded in the pharmaceutical and nutraceutical industries. It is used in a variety of therapeutic methods; nevertheless, it is important to note that the herb is used extensively in the treatment of Alzheimer's disease. It is a degenerative disease that impairs memory and other mental skills in elderly people.

Scientists are increasingly resorting to ayurvedic herbs like triphala, shatavari, and brahmi to treat ailments. In the treatment of epilepsy, chickenpox, and paediatric disorders, brahmi juice plays a critical role in assisting, treating, and speeding up recovery. The herb's use as a functional food ingredient in the food processing industry is expected to grow in popularity in the coming years. Furthermore, it has a wide range of applications in the cosmetics business. Brahmi has a lot of benefits for skin rejuvenation.

Functional beverages must satisfy two basic purposes: first, they must have nutritional value, and second, they must provide acceptable sensory functions including flavour and texture. Processing herbal plants into functional beverages protects the bioactive chemicals' content and potential to enhance the immune system, as well as providing safety for the end goods.

According to TATA 1mg, recommended dosage of brahmi

- a. 2-4 tablespoons of brahmi Juice once a day
- b. 14-12 teaspoon brahmi churna twice a day
- c. Brahmi Capsules – Take 1-2 capsules twice day.
- d. Take 1-2 brahmi pills twice a day.
- e. 3-4 tablespoons of brahmi infusion once or twice a day

Uses of Brahmi in food processing

1. Fresh Brahmi Juice

- a. Take 2-4 tablespoons of freshly squeezed brahmi juice.
- b. Mix in an equal amount of water and drink once a day before eating.

2. Brahmi churna

- a. Measure 1/4 to 1/2 teaspoon brahmi churna.
- b. Take it before or after lunch and dinner with honey.

3. Brahmi capsule

- a. Take 1-2 capsules of brahmi.
- b. Take it with a glass of milk before or after lunch or dinner.

4. Brahmi tablet

- a. Take one or two brahmi tablets.
- b. Drink it with milk either before or after lunch or dinner.

5. Brahmi cold infusion

- a. Take one or two brahmi tablets.
- b. Drink it with milk either before or after lunch or dinner.

Rasayana drugs from the ayurvedic system of medicine as possible radio-protective agents in cancer treatment. Rasayana medications have been used by Indians from the dawn of civilization, giving them an advantage over manufactured drugs. When opposed to their synthetic competitors, the benign nature of rasayana medicines provides a significant benefit in that they can readily be approved for human trials and at lower costs. It is predicted that the organ-specific brahma rasayana would be effective in brain and gastrointestinal tumours when used as a radio-protective drug in clinics (Baliga et al., 2013).

Brahmi is used to treat bronchitis, chronic cough, asthma, hoarseness, arthritis, rheumatism, backache, fluid retention, blood cleanser, chronic skin conditions, constipation, hair loss, fevers, digestive problems, depression, mental and physical fatigue, and many other ailments in traditional Indian medicine. It's used to treat psoriasis, abscess, and ulceration, among other skin

conditions. It promotes the development of skin, hair, and nails. It is used to alleviate tension and anxiety. Brahmi possesses antioxidant qualities, according to Ayurveda. It has been shown to lower lipid oxidation in the blood, which is a risk factor for cardiovascular disease. Brahmi is believed to be the key revitalising herb for nerve and brain cells (Tamboli et al., 2022).

Anon (2021) analysed in medicinal uses of brahmi in traditional Indian medicines for the treatment of bronchitis, chronic cough, asthma, hoarseness, arthritis, rheumatism, backache, fluid retention, blood cleanser, chronic skin conditions, constipation, hair loss, fevers, digestive problems, depression, mental and physical fatigue and many more. It is used to treat all sorts of skin problems like eczema, psoriasis, abscess and ulceration. It stimulates the growth of skin, hair and nails. It is taken to get relief from stress and anxiety. According to the ayurveda, brahmi has antioxidant properties. It has been shown to lower lipid oxidation in the blood, which is a risk factor for cardiovascular disease. Brahmi is regarded as the most important herb for the rejuvenation of nerve and brain cells and the chemical composition of brahmi leaves are presented in Table 2:

Table 2: Chemical composition of fresh Brahmi leaves per 100 g (Source: Devendra et al., 2018)

Component	Amount (per 100 g)
Moisture	88.4 g
Carbohydrates	5.9 g
Crude Protein	2.1 g
Total Ash	1.9 g
Crude Fiber	1.05 g
Crude Fat	0.6 g
Calcium	202.0 mg
Iron	7.8 mg
Energy	38 cal

Value-addition of Brahmi in food processing

Drying is one of the earliest preservation methods known to mankind, with evidence dating back to prehistoric times. Dried foods play an essential role in the food supply chain in today's market. Fruits and vegetables are expected to make up around 1% of the overall drying in the food business, with grains being the most important. The fundamental aspect of this method is that it reduces the water content in order to prevent or delay food spoiling caused by microorganisms. When drying nutraceutical or functional food industries, there are a number of factors to consider. A system that reduces exposure to light, oxidation and heat (i.e. less time duration with high heat 70°C) may aid in the conservation of important bioactive chemicals (Ahmed, 2013).

Before drying, pretreatments are processing procedures that attempt to produce high-quality dried herbs while also lowering drying time and energy usage (Deng et al., 2019). Many types of herbs benefit from blanching when drying. Blanching has a number of advantages, the most important of which is the reduction of colour deterioration. Blanching herbs was said to shorten their drying time. In comparison to untreated leaves, steam blanching for 15 seconds boosted the drying rate by a factor of ten. The steam blanched dried leaves retain their colour better and have a higher chlorophyll a/b ratio (Rocha et al., 1993).

Drying freshly collected herb in a hot air oven at 37-42°C, then powdering and sifting the dried herb to obtain a 30-40 mesh size powder. Defat the powdered herb using hexane. Extract the defatted powdered herb using methanol to extract the same herb again to generate a bacoside-rich extract. Under reduced pressure, the extract is concentrated to one twentieth of its original volume. To precipitate the bacosides, gradually add the concentrated extract to acetone. Filtration of the bacosides in a vacuum

filter, with the crude bacoside material dissolved in 2-10 parts water. Using n-butanol to extract the bacoside solution and selectively transfer the bacosides to the solvent phase. To obtain semi-dry mass, separate and concentrate the solvent phase under vacuum. Combining 2-10 parts water with the semi-dried mass. To obtain a stable free flowing fraction of brahmi is rich in bacosides, spray dry the stabilised bacoside solution while maintaining a hot air temperature of 90-110°C (Kahol et al., 2004). At bedtime, mix 3 g of brahmi powder with 100 mL of cow's milk. It alleviates insomnia. Barnyard millet is a underutilized grain that can be used to make millet- based designer vermicelli with useful ingredients (2% germinated fenugreek seed, garden cress seed, ekanayakam root barks and 0.5 percent brahmi leaves powder). With an overall acceptability of 8.02 and 8.22, brahmi-based vermicelli constructed with (40: 59.5: 0.5) germinated barnyard millet, whole wheat flour and brahmi were highly acceptable (Anon, 2018).

Functional drinks have a variety of advantages, especially in pandemic situations like the one we're in right now. Consumption of nutrient-dense foods and beverages is a daily requirement to prevent disease from attacking the body. Because the bioactive substances found in these foods can fend off free radicals created both within the body and externally effects, consuming functional meals or drinks becomes an alternative to healthy living. In order to obtain food that is healthy and safe for the body, these foods and drinks must be free of physical, chemical and microbiological contamination (Pamela et al., 2021).

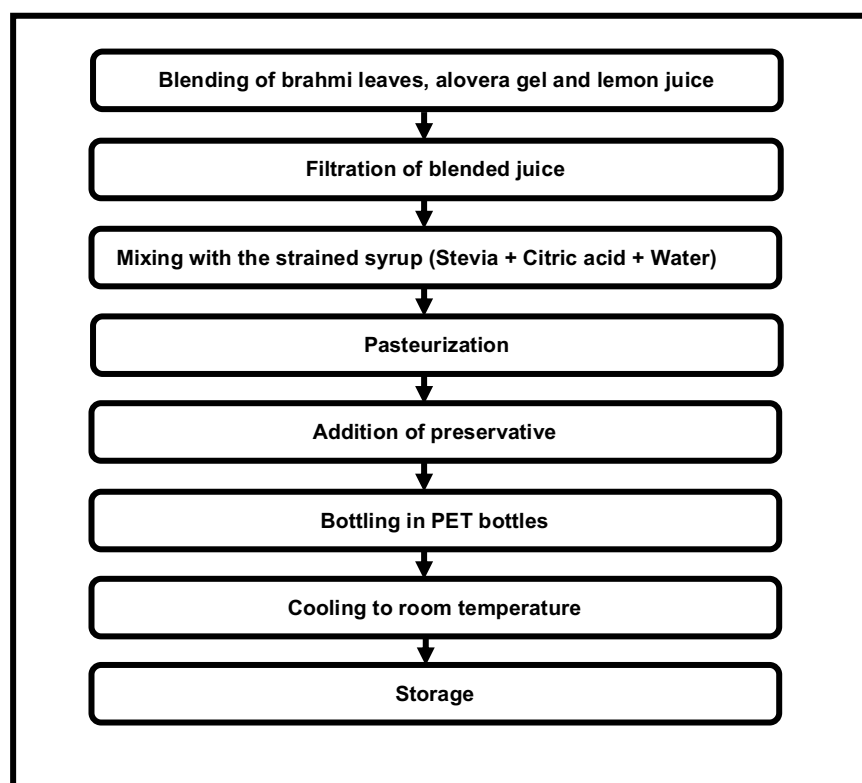


Fig 2: Process flow chart for the development of Ready to Serve drink of brahmi with alovera-lemon drink

Alovera gel, fresh lemon juice and the fresh brahmi leaves will be blended in juicer and will be filtered by muslin cloth, pasteurized at 70°C for 30 minutes. The required amount of stevia and citric acid were dissolved in water to prepare syrup up to boiling stage, and strained through the muslin cloth and added after cooling, to get the desired TSS of 14 to 20 °Brix (Afreen et al., 2016). The process flow chart for the development of Ready to Serve drink of brahmi with alovera-lemon drink is presented in fig 2.

Zaker et al. (2014) standardized recipe for preparation of composite flour based herbal biscuits with different Indian medicinal herbs viz., brahmi, lemongrass, shilajit, makoi, kasni and badiyan and their effect on sensorial quality characteristics were investigated. They concluded that optimum concentration of different herbs viz., brahmi, lemon grass, shilajit, makoi, badiyan, kasni for development of herbal biscuits were 0.5 g, 0.5 g, 0.5 g, 5 mL, 10 mL and 5 mL, respectively.

Ghodke and Kale (2017) developed carrot-brahmi biscuits to study effect of incorporation of carrot and brahmi powder in biscuits. Three types of biscuits were prepared by replacing refined wheat flour with 20 per cent of carrot powder and 0.5, 1 and 1.5 per cent of brahmi powder. The sensory score of biscuit prepared by 20 per cent carrot powder and 1 per cent brahmi powder was found to be rated high as compared to the other levels of carrot and brahmi powder with overall acceptability of 8.2. Kumar et al. (2018) prepared an herbal whey beverage with extracts of brahmi at various levels (1.5, 2.5 and 3 per cent). Proximate analysis of final herbal beverage showed an increase in acidity and microbial content. The herbal beverage was optimized with 3 per cent brahmi, 16 per cent sucrose and 0.4 per cent calcium gluconate.

Menkudale and Pawar (2018) investigated on physico-chemical analysis of brahmi ghrta prepared from puran ghrta and fresh goghrita. As a milk decoction, brahmi is a good brain tonic, particularly if combined with ashwagandha. When combined with ghee or milk, brahmi has a tonifying, nerve nourishing and pitta cooling effect. Brahmi combined with other herbs, its medicated qualities are expanded. Brahmi rasayana with 10 parts brahmi, 40 parts sugar, 2 parts clove and one part each of cardamom and pippali, worked as an anti-inflammatory and nerve tonic agent.

Verma and Mishra (2021) reported on preparation of herbal products (brahmi, ashwagandha and curcumin) using plant extract to cure dementia patients. Herbal inclusion can give the product a fresh flavour in addition to its medical benefits. Brahmi is a highly prized plant used in ayurvedic treatment and has been used and grown for a very long time in India. The brahmi powder was combined right away with the other components of the product. The research and findings of their tests indicate that adding brahmi is the most practical way to produce herbal products with better nutritional value and satisfying sensory qualities.

CONCLUSION

The incorporation of brahmi (*Bacopa monnieri*) in Postharvest Technology shows great promise and potential. The herb's proven antioxidant properties offer a natural and effective means to combat postharvest losses induced by oxidative stress. By neutralizing harmful free radicals, Brahmi extracts can significantly extend the shelf life of various perishable commodities, preserving their quality and nutritional value for longer periods. Additionally, brahmi's antimicrobial activities present a sustainable alternative to synthetic preservatives, addressing concerns over chemical residues and potential health risks. Implementing brahmi-based treatments can inhibit the growth of spoilage microorganisms, reducing the likelihood of foodborne illnesses and improving overall food safety. Furthermore, the integration of brahmi into postharvest practices aligns with the growing demand for eco-friendly and organic solutions in the food industry. Its natural origin and low environmental impact contribute to a more sustainable approach to agriculture and food preservation. Scientists and industry professionals should collaborate to fully understand the herb's mechanisms of action and its compatibility with different crops and storage conditions. In conclusion, Brahmi's emergence in Postharvest Technology heralds a new era of innovative and sustainable preservation methods. Embracing this ancient medicinal herb can revolutionize the way we handle and store agricultural produce, benefiting farmers, consumers, and the environment. As we strive for more efficient and ethical food systems, the exploration of Brahmi's full potential remains a compelling avenue for future research and development in the field of postharvest preservation.


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