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Development and quality evaluation of a functional nutribar incorporated with brahmi (*Bacopa monnieri*) powder

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Abstract
The present study aims to develop and evaluate functional nutribars incorporated with Brahmi (*Bacopa monnieri*) powder, as well as oats, dates, nuts and seeds. Six formulations (T_0-T_5) were created and tested for sensory acceptability with a nine-point Hedonic Rating Scale. T_2 had the highest sensory score (8.60) and was selected for further research. The chosen nutribar had moisture (9.5g/100g), protein (8.5g/100g), fat (11g/100g), carbohydrate (46.02g/100g), crude fiber (7g/100g), and 313.91 kcal/100 g energy. Calcium and iron content were 121.10 mg/100g and 3.58 mg/100g. The study found that incorporating brahmi powder into nutribar improves its nutritional and functional qualities

Keywords: Nutribar, brahmi, functional foods, oats, pumpkin seed, almond, ragi vermicelli

Introduction

Convenience food are ready-to-eat, ready-to-cook, and semi-processed items that require minimal preparation, save time, and offer portability and extended shelf life—are in high demand due to modern living, fast urbanization, and shifting eating patterns. Busy schedules, smaller households, higher earnings, and a need for quick, easily accessible meals are the reasons for their appeal (Imtiyaz *et al.*, 2021) [11]. Convenience foods have grown to be a significant part of the contemporary food market because they give urban people with little time for conventional meal preparation useful dietary options (Dhir & Singla, 2020) [9].

Nutribars are handy, ready-to-eat snack items that offer balanced nutrition and practical health advantages. They are made with cereals, nuts, seeds, dried fruits, and natural sweeteners (Joshi *et al.*, 2023) [12]. These nutrition bars are excellent sources of vitamins, minerals, fiber, protein, and complex carbohydrates. They also use a range of ingredients to appeal to different consumer demographics (Samuel & Peerkhan, 2020) [21]. In recent years, bar production has accelerated, and the worldwide market has expanded the variety of these bars according to consumer preferences. In 2007, the global rate of nutrition bar consumption rose to 11%, or over USD 4 billion in markets (Sharma *et al.*, 2014) [22]. Moreover, youthful customers are shown a strong interest in locally produced nutrition bars (Padmashree *et al.*, 2011) [14].

Functional foods are goods that include diverse biologically active components that, when ingested in a current diet, contribute to preserving the population's ideal condition of physical, mental, and mental health
(Csapó *et al.*, 2019a) [7]. These foods can have unique functional benefits for many devices and systems, including the digestive system, immunological system, cardio-circulatory system, and even the cell. These foods have long been enjoyed by people all over the world due to their health benefits, despite the fact that the biological active chemicals they contain have just recently been recognized and defined (Csapó *et al.*, 2019b) [7].

Bacopa monnieri (Brahmi) is an Ayurvedic herb used to boost memory and cognitive function, treat neurological disorders, and acts as a rejuvenator with multiple medicinal properties including antioxidant, neuroprotective, anti-inflammatory, and antidepressant effects (Devendra *et al.*,2018) [8]. Pumpkin seeds contain bioactive compounds and have potential as a functional food element. It is used in a variety of baking, dairy, confectionery, snack, and bar products (Fatima *et al.*, 2025) [10]. Oats also contain significant amounts of other beneficial chemicals such as phenolic acids, tocols, sterols, avenac osides, and avenanthramides, which aid to prevent diabetes, cancer, and CVD illnesses (Paudel *et al.*, 2021) [16]. Finger millet has a high calcium and potassium content and is utilized in the making of noodles, vermicelli, and spaghetti (Shobana *et al.*, 2013) [23]. Date fruit (*Phoenix dactylifera L.*) is well known for both its rich profile of useful bioactive chemicals and its energy-dense nutritional. These substances, which are mostly polyphenols, flavonoids, dietary fiber, and carotenoids, have a variety of beneficial impacts on health, such as antioxidant, anti-inflammatory, antimicrobial, and metabolic advantages (Akhter *et al.*, 2025) [1]. Almonds are regarded highly nutritious due to their rich amount of fat and proteins, and they prevent diabetes and cardiovascular disease (Siddiqui & Begum, 2023) [24].

The aim of the present study was to develop and evaluate functional nutribars incorporated with Brahmi (*Bacopa monnieri*) powder along with oats, almonds, ragi, raisins, pumpkin seeds, and dates in different formulations, and to assess their sensory, nutritional, phytochemical, shelf-life, and microbial quality characteristics.

Material and Method

Materials and chemicals

Brahmi (*Bacopa monnieri*) powder, oats, almonds, ragi flour, raisins, pumpkin seeds, and dates used for the preparation of functional nutribars were procured from local markets and commercial suppliers. All ingredients were cleaned, sorted, and stored in airtight containers under hygienic conditions until further use. Food-grade ingredients and analytical grade chemicals used for nutritional were obtained from certified suppliers.

Methods

Raw materials and nutribar manufacture

Dates were deseeded and coarsely chopped to achieve a consistent texture for use as a natural binder in the nutribar recipe. Almond and pumpkin seeds were washed and lightly toasted to improve flavor and texture. Raisins were cleaned and dried to remove any surface contaminants. Oats and ragi flour were sieved for consistent particle size, and Brahmi (Bacopa monnieri) powder was stored in airtight, moisture-proof containers until used in nutribar manufacture.

Six formulations of functional nutribars designated as T_0 (control), T_1, T_2, T_3, T_4, and T_5 were prepared by varying the proportions of Brahmi (*Bacopa monnieri*) powder and oats, while keeping the quantities of almonds, ragi vermicelli, raisins, pumpkin seeds, dates and jaggery constant (Table 1).

Table 1: Ingredient composition of different treatments of brahmi incorporated nutribar

Ingredients	T_0 (Control)	T_1	T_2	T_3	T4	T_5
Brahmi powder (g)	--	2g	4g	6g	8g	10g
Oats (g)	40g	38g	36g	34g	32g	30g
Dates (g)	20g	20g	20g	20g	20g	20g
Jaggery (g)	20g	20g	20g	20g	20g	20g
Pumpkin seed (g)	5g	5g	5g	5g	5g	5g
Almond (g)	5g	5g	5g	5g	5g	5g
Raisins (g)	5g	5g	5g	5g	5g	5g
Ragi vermicelli (g)	5g	5g	5g	5g	5g	5g

Functional Brahmi nutribars were prepared by roasting oats, ragi vermicelli, pumpkin seeds, raisins, and almonds. The roasted ingredients were cooled and coarsely ground. Dates were ground into paste and jaggery was melted with a small quantity of water. Brahmi (*Bacopa monnieri*) powder was mixed with the ground ingredients, followed by the addition of date paste and melted jaggery to form a uniform mass. The mixture was shaped into bars, refrigerated for 30 minutes, and packed in airtight containers.

Sensory analysis

Sensory evaluation was carried out using the method of Swaminathan (1974) [26] with some modifications. A semi-trained panel of 15 judges was selected based on interest, availability, and prior sensory evaluation experience. Panelists evaluated each formulation for appearance, colour, flavour, texture, taste, and overall acceptability using a nine-point hedonic scale, where 9 indicated 'like extremely' and 1 indicated 'dislike extremely'. Samples were coded and presented in randomized order to minimize bias.

Nutritional analysis

Estimation of Moisture, Carbohydrate, Protein, Fat, Fibre, and Energy

The best-performing treatment (T_2) was selected for nutritional analysis.

Moisture content was estimated according to AOAC (2023). About 2g of sample weighed and dried in hot air oven at 105**°C** until constant weight is obtained

Total carbohydrate content was determined by the Anthrone method of Sadasivam and Manickam (1992), and absorbance was measured at 630 nm and the carbohydrate content was calculated using a standard glucose curve and expressed as g/100g of a sample

Protein content was determined according to the Kjeldahl method AOAC (2023), the sample was digested with concentrated sulfuric acid in the presence of a catalyst, followed by distillation and titration of the released ammonia nitrogen, and the crude protein content was calculated by multiplying the nitrogen value by a conversion factor of 6.25

Fat content was determined using the Soxhlet extraction method as described by AOAC (2023). The dried sample was extracted continuously with petroleum ether (or diethyl ether) in a Soxhlet apparatus for 6 hours, after which the solvent was evaporated, and the residual crude fat was weighed and expressed as a percentage of the original sample weight.

Crude fibre content was estimated by the acid–alkali digestion method described by Chopra and Kanwar (1978)

The energy value of the samples was calculated using Atwater conversion factors, and all results were expressed on a per 100 g basis.

Estimation of Iron, Calcium

Iron content was estimated by the colorimetric method using potassium thiocyanate, which forms a blood red complex with ferric ions (Raghuramulu *et al.,* 2003) [17]. Absorbance was measured at 540 nm and iron content was calculated using a standard curve and expressed as mg/100 g.

Calcium content was estimated by the EDTA titration method by Page (1982) [15]. The sample was digested with nitric acid and perchloric acid mixture, and the extract was titrated with 0.02 N EDTA using calcone indicator until a permanent blue colour appeared. Calcium content was expressed as mg/100 g of sample.

Results

Sensory evaluation of brahmi incorporated nutribar

The sensory evaluation of Brahmi-incorporated nutribar formulations showed variations in appearance, colour, flavour, texture, taste, and overall acceptability.

Among all treatments, T_2 recorded the highest mean sensory score (8.60), indicating superior sensory quality and consumer acceptance. Sensory scores decreased progressively from T_3 to T_5, with T_5 showing the lowest mean score (6.83). The decline in sensory attributes at higher levels of Brahmi incorporation may be due to its characteristic bitter taste and herbal flavour, affecting overall acceptability. Therefore, T_2 was selected as the most acceptable formulation

Table 2: Mean sensory scores of brahmi incorporated nutribar

Treatment	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability	Total Mean Score
T0	8.4	8.3	8.2	8.1	8.6	8.3	8.32
T1	8.2	8.1	8.0	8.0	8.1	8.2	8.2
T2	8.7	8.6	8.5	8.6	8.4	8.8	8.60
T3	7.9	7.8	7.6	7.5	7.4	7.7	7.65
T4	7.5	7.4	7.2	7.1	7.0	7.3	7.25
T5	7.1	7.0	6.8	6.7	6.5	6.9	6.83

Nutritional composition of selected Nutribar formulation (T_2)

The changes in nutritional composition of the optimized sorghum nutribar formulation (T_t) are shown in Table 3. The total energy value was 313.91 kcal/100 g with a carbohydrate content of 46.02 g/100 g, protein 8.5/100 g, fat 11%, crude fibre 7%, and moisture 9.5%, Mineral analysis revealed calcium at 121.10mg/100 g, and iron at 3.58mg/100 g.

Table 3: Nutritional composition of selected brahmi incorporated nutribar (T_3)

Nutrient	Composition (per 100 g) T_2
Moisture (%)	9.5 %
Carbohydrate (g/100 g)	46.02 g
Protein (g/100 g)	8.5g
Fat (%)	11%
Crude Fibre (%)	7%
Calcium (mg/100 g)	121.10 mg
Iron (mg/100 g)	3.58 mg
Energy (kcal/100g)	313.91 kcal

Discussion

The sensory acceptance of the produced brahmi-enriched energy bars was significantly influenced by compositional variation between formulations. The optimal formulation was determined to be T_2, as research on cereal bar formulations consistently shows that sensory scores peak at a moderate ingredient level, with the combination of cereals, fruits, and sweeteners having a direct impact on consumer product acceptance (Samakradhamrongthai *et al.*, 2021) [20]. T_2, with 4 g of brahmi powder and 36 g of oats, had the highest total mean sensory score of 8.60, demonstrating the best balance of functional enrichment and sensory appeal. Sensory assessment studies on cereal-based energy bars have found that the combination of base ingredients greatly affects preference rating scores, and that raising any ingredient beyond its optimum level causes a decrease in consumer liking (Samakradhamrongthai *et al.*, 2021) [20].

T_2, which contained 4 g of brahmi powder and 36 g of oats, got the greatest overall mean sensory score of 8.60, indicating the finest balance of functional enrichment and sensory appeal. Sensory assessment tests on cereal-based energy bars discovered that the combination of base ingredients has a significant impact on preference rating scores, and that increasing any ingredient above its optimum level reduces consumer liking (Saloni *et al.*, 2022) [19].

The T_0 control and T_1 had competitive sensory scores of 8.32 and 8.20, respectively, indicating that the basic formulation was naturally well-accepted. The incorporation of natural sweeteners such as dates and jaggery alongside dried fruits in energy bars boosts the energy value and overall palatability, adding positively to baseline sensory acceptance (AlJaloudi *et al.*, 2024a). Energy bars made with oats, dates powder, and jaggery powder exhibit adequate sensory, textural, and nutritional properties, indicating their potential as a functional bar matrix (Joshi Assistant Professor *et al.*, 2022) [13].

The proximate composition of the optimized T_2 formulation showed a nutritionally strong profile, with a protein level of 8.5 g/100 g. The integration of oats and seeds in snack bar formulations has been shown to boost the level of protein, minerals, dietary fiber, essential amino acids, phenolic compounds, and antioxidant activity (Singh *et al.*, 2022) [13]. Oat-based energy bars with nuts and seeds have been shown to include crude protein content ranging from 8 to 20%, establishing them as functional ergogenic aids for health-conscious individuals (S. ARCHANA *et al.*, 2024) [4]. T_2 has a carbohydrate value of 46.02 g/100 g and is predominantly sourced from oats, dates, jaggery, and ragi vermicelli, providing a steady energy source. Oats contain water-soluble β-glucan, a physiologically active component that lowers postprandial glycemia and fasting plasma cholesterol, making them valuable functional food matrices (Wang & Ellis, 2014) [27].

The energy value of 313.91 kcal/100 g is appropriate for a functional energy bar aimed at active individuals. High-energy bars produced with functional ingredients such as dried fruits and seeds have been demonstrated to give enriched nutritionally important food options for consumers, with total phenolic, flavonoid, and fiber content much greater than control formulations (AlJaloudi *et al.*, 2024b). The Brahmi Nutribar's 11% fat level balances its higher fiber content and is comparable to plant-based snack bars (Constantin *et al.*, 2019). T_2's functional profile is further improved by 7% crude fiber. Low water activity snack bars with sufficient fiber content are categorized as low moisture food products, and their low water activity values prolong shelf life by preventing the formation of mold and yeast (Pratiwi *et al.*, 2019).

T_2's mineral profile showed a calcium content of 121.10 mg/100 g and an iron content of 3.58 mg/100 g, both of which significantly contributed to the daily requirements for micronutrients. These benefits are mostly due to the addition

of ragi vermicelli, since finger millet is a proven source of calcium and iron that provides vital minerals and amino acids that promote bone health and aid in the treatment of diseases including diabetes, osteoporosis, and anemia (Amir Gull, 2014).

T_2's moisture content of 9.5% is within the permissible range for goods that are shelf-stable. Since water activity below 0.65 efficiently inhibits the growth of yeast and mold in cereal-based snack products, low moisture content is crucial for preserving microbiological integrity (Pratiwi *et al*., 2019). The nutri bar gains substantial functional benefit when brahmi (Bacopa monnieri) is added at 4 g in T_2. The main bioactive components, bacosides A and B, are widely known for their antioxidant, neuroprotective, and memory-boosting qualities (Aguiar & Borowski, 2013).

Conclusion

It is clear from the findings and discussion that the created nutribar formulations' sensory and nutritional qualities were greatly impacted by varying amounts of Brahmi powder. T_2 (4 g Brahmi powder) had the greatest overall acceptance score (8.60) of all the treatments, indicating balanced sensory qualities and higher customer choice. With 8.5 g/100 g protein, 7 g/100 g crude fiber, 121.10 mg/100 g calcium, and 3.58 mg/100 g iron, the improved formulation also showed notable nutritional value. Sensory scores gradually decreased as the amount of Brahmi powder was increased over 4 g. This was mainly because larger concentrations of Brahmi are associated with a distinctive herbal flavor and a slight bitterness Therefore, T_2 is recommended as the optimum formulation for large-scale production, as it provides enhanced nutritional benefits while maintaining excellent sensory acceptability and consumer preference.

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