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Value Addition of Chutney Powder Using Brown Top Millet (*Brachiaria ramosa*)

Harini G.[1]; Shekhara Naik R.[2]

[1]Research Scholar; [2]Professor and Head
[1;2]Department of Food Science and Nutrition, Yuvaraja's College, University of Mysore, Mysuru, Karnataka, India

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Abstract: Growing consumer interest in nutrient-dense and functional convenience foods has accelerated the utilization of underexploited millets in traditional food formulations. Brown top millet (BTM) (*Brachiaria ramosa*), known for its rich dietary fibre, mineral content, and bioactive components, was incorporated into chutney powder formulations to enhance nutritional quality and promote millet-based value addition. The developed formulations were evaluated for sensory attributes, nutritional composition, and storage stability. Sensory evaluation was carried out using a nine-point hedonic scale to assess appearance, colour, aroma, taste, texture, and overall acceptability. The optimized formulation exhibited desirable organoleptic characteristics and received higher acceptability scores, indicating the suitability of brown top millet incorporation in traditional chutney powder without adversely affecting sensory quality. Nutritional analysis revealed improved dietary fibre, ash, and mineral content in the millet incorporated variation compared to the conventional formulation. The product also contained appreciable amounts of protein and complex carbohydrates, demonstrating enhanced nutritional density attributable to the incorporation of brown top millet. The presence of resistant starch and phenolic compounds may further contribute to the functional and health-promoting properties of the developed product. Storage stability studies were conducted under ambient conditions to evaluate physicochemical, oxidative, and microbiological quality during storage. Parameters including moisture content, free fatty acid value, peroxide value, and microbial load were monitored periodically. The developed chutney powder maintained acceptable sensory and oxidative stability throughout the storage period, while microbial counts remained within permissible limits, indicating satisfactory shelf stability and microbiological safety. The findings highlight the potential of brown top millet as a functional ingredient for the development of nutritionally enriched and shelf-stable traditional food products. Incorporation of brown top millet in chutney powder formulations may serve as an effective approach for promoting millet consumption and developing health-oriented convenience foods.

Keywords: *Brown Top Millet; Chutney Powder; Value Addition; Sensory Evaluation; Nutritional Composition; Storage Stability; Millet-Based Functional Foods.*

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I. INTRODUCTION

Millets are regarded as nutritionally superior cereals and have gained increasing importance due to their potential role in ensuring food and nutritional security, particularly in semi-arid and resource-limited regions. In recent years, there has been growing interest in underutilized millets because of their resilience to adverse climatic conditions, low agricultural input requirements, and superior nutritional profile compared to major cereals (Saleh et al. 2013). Among the small millets, brown top millet (*Brachiaria ramosa*) is an indigenous and underexploited crop cultivated in parts of India and Africa. It is known for its rich content of dietary fibre, minerals, slowly digestible starch, and bioactive compounds that contribute to several health-promoting properties (Amadou et al. 2013).

Brown top millet possesses considerable nutritional significance owing to its high fibre and micronutrient content. Millets are generally rich in calcium, iron, magnesium, phosphorus, and antioxidant phytochemicals, which play a crucial role in reducing the risk of chronic diseases such as diabetes mellitus, obesity, cardiovascular disorders, and gastrointestinal complications (Chandrasekara and Shahidi, 2011). The presence of phenolic compounds and resistant starch in millets contributes to lower glycaemic response and improved gut health (Devi et al. 2014). According to Taylor and Emmambux (2008), millet-based foods also exhibit excellent functional properties suitable for the development of gluten-free and health-oriented food products.

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Traditional chutney powders are widely consumed in Indian households as convenient ready-to-eat condiments due to their characteristic flavour, ease of preparation, and longer shelf life. These products are commonly prepared using roasted pulses, spices, curry leaves, oilseeds, tamarind, and condiments. Although chutney powders contribute appreciable amounts of protein and flavouring components, their nutritional enhancement through incorporation of functional cereal ingredients remains relatively unexplored. Incorporating millets into traditional food products can improve dietary fibre, mineral content, and overall nutritional quality while maintaining consumer acceptability (Muthamilarasan and Prasad, 2021; Malleshi, 2006).

Value addition of millet-based products has emerged as an important strategy for promoting millet consumption and diversification of functional foods. Previous studies have demonstrated successful incorporation of millets into bakery products, snack foods, extruded products, instant mixes, and complementary foods with improved nutritional and functional characteristics (Rao et al. 2017).

Considering the increasing consumer preference for health-oriented convenience foods and the need for utilization of underexploited millets, the present investigation was undertaken to develop a value-added chutney powder using brown top millet (*Brachiaria ramosa*) and to evaluate its nutritional, functional, and sensory characteristics.

II. MATERIALS AND METHODS

The present investigation was carried out at Department of Food Science and Nutrition, located in Yuvaraja's College- an autonomous institution affiliated with the University of Mysore in Mysuru. The key ingredients were procured from the Brown top millets were procured from Dhatu Organics & Naturals, an organic store located in Mysore. The other raw materials required for the preparation of the products were procured from local markets local market of the Mysuru, Karnataka.

- *Development of Chutney Powder*

The standard chutney powder was prepared by adapting the method described by Kannebonia et al. (2023) with slight modifications. Channa dhal and urad dhal were used as base ingredients in standard preparation. In value added formulation, channa dhal and urad dhals were replaced by dehulled brown top millet. The preparation procedure adopted for the development of standard and brown top millet-incorporated chutney powder is illustrated in *Figure 1*. Three different variations were prepared viz., V1- 20%, V2- 25% and V3-30%. The prepared products were subjected to sensory analysis and the optimised one along with standard were considered for further analysis. The standard and brown top millet-incorporated chutney powder formulations developed at different incorporation levels are presented in *Figure 2.*

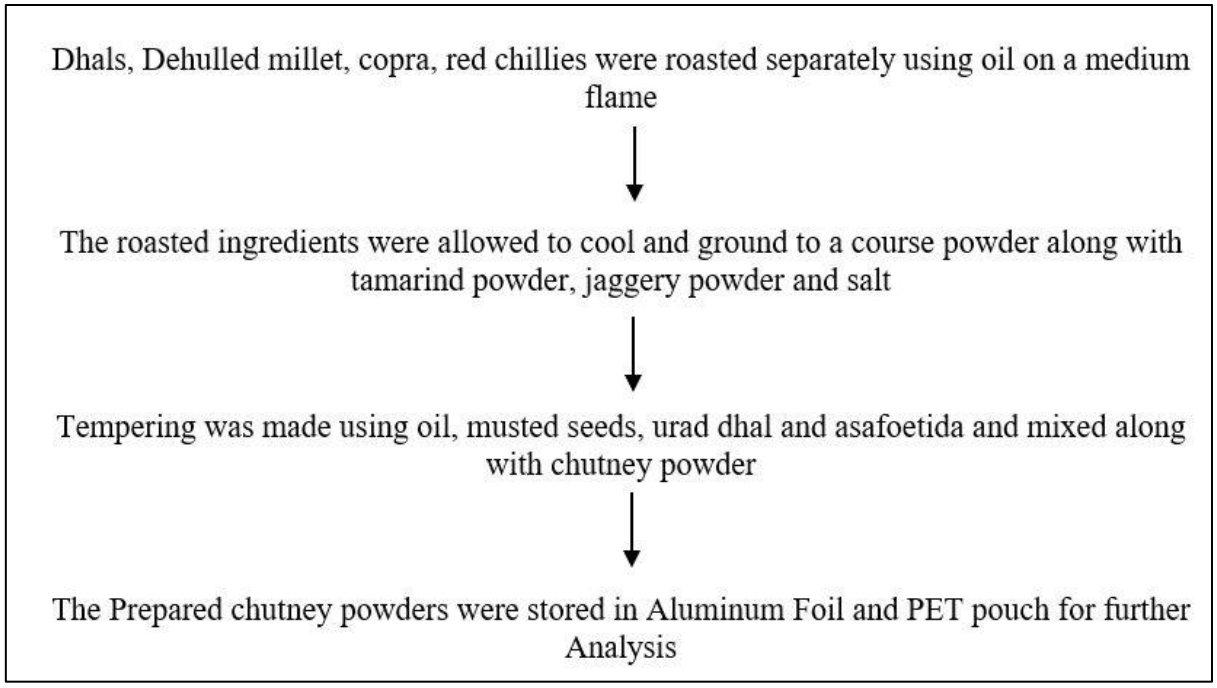


Fig 1 Preparation of Chutney Powder

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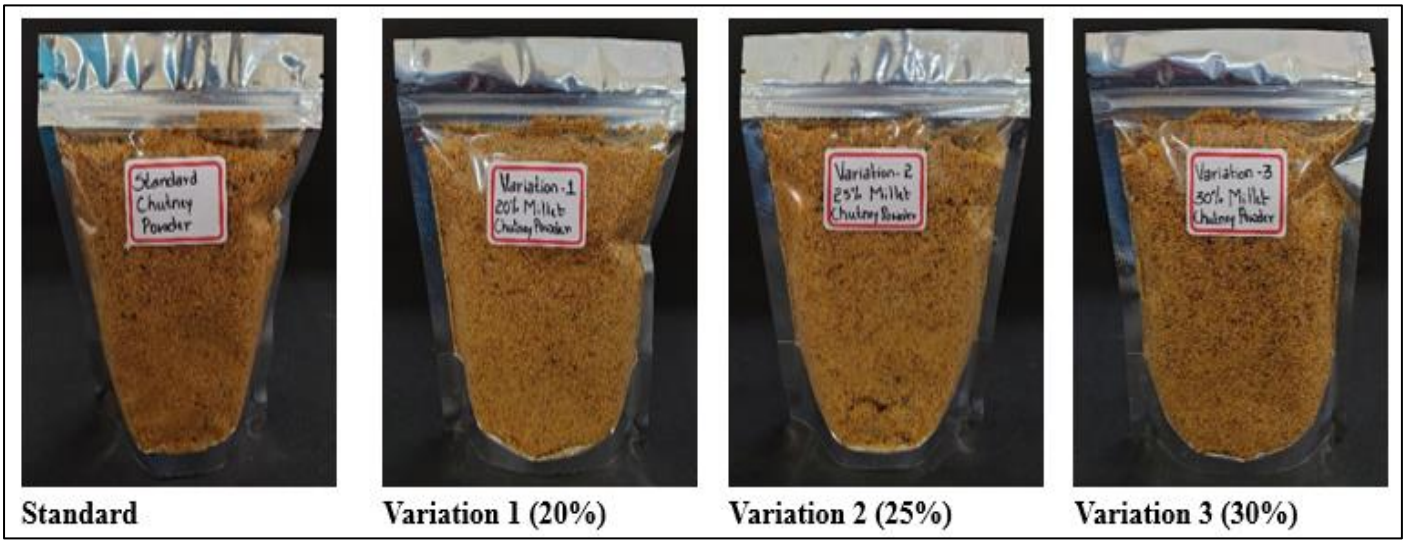


Fig 2 Standard and Millet Chutney Powder

➢ *Standardization of Chutney Powder*

The process of standardization refers to the trial-and-error method where the different quantities of ingredients were used to develop a satisfactory quality, quantity and yield of the final finished product. It is a gradual process carried out till and acceptable recipe for preparation of the product will be obtained. The recipe was standardised by assessing the organoleptic properties of the prepared products. The standardization of recipe is detailed under *Table 1*. Appearance, colour, flavour, taste, texture and overall acceptability. The sensory evaluation was carried out by 30 trained and semi-trained panel members.

Table 1 Standardization of Chutney Powder Recipe

Ingredients	Standard	Variation 1	Variation 2	Variation 3
For Chutney Powder Preparation				
Channa Dhal (g)	56	44.8	42	**39.2**
Urad Dhal (g)	56	44.8	42	**39.2**
Brown top Millet (Dehulled) (g)	0	22.4	28	**33.6**
Copra (g)	20	20	20	**20**
Oil (ml)	10	10	10	**10**
Red Chillies Byadagi (g) Guntur (g)	 10 8	 10 8	 10 8	 **10** **8**
Tamarind Powder (g)	7	7	7	**7**
Jaggery Powder (g)	6	6	6	**6**
Salt (%)	2	2	2	**2**
For Tempering				
Oil (ml)	5	5	5	**5**
Mustard seeds (g)	2.5	2.5	2.5	**2.5**
Urad Dhal (g)	5	5	5	**5**
Asafoetida (g)	1.5	1.5	1.5	**1.5**

➢ *Sensory Analysis of Chutney Powder*

Sensory evaluation of the developed chutney powder was conducted by serving the products to 30 semi-trained panellists for 6 attributes namely appearance, colour, flavour, taste, texture and overall acceptability. Prior to sensory evaluation, the panellists were acquainted with commercially available chutney powder products. The panellists were then asked to evaluate the samples using a nine-point hedonic scale, where a score of 9 represented 'like extremely' and a score of 1 represented 'dislike extremely' Stone and Sidel (2004).

➢ *Proximate Analysis of Chutney Powder*

The proximate analysis of standard and optimized variation was conducted in triplicate using A.O.A.C. (2016) methods for basic nutritional composition of chutney powder— comprising moisture and ash (A.O.A.C., 2016). Protein, fat, crude fibre, and carbohydrate contents were determined using standard analytical procedures prescribed by AOAC (2005). Moisture determination was carried out by drying the samples at 100°C until a constant weight was obtained. Ash content was determined by muffle furnace incineration at 650–700°C for 8 h and quantification of the residual mineral matter. Crude fibre content was determined following standard analytical procedures, whereas fat extraction was carried out using a Soxhlet apparatus with

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petroleum ether as the extraction solvent. Protein content was estimated by the Kjeldahl method using a nitrogen conversion factor of 6.25. Carbohydrate content was calculated by difference after subtracting the percentages of moisture, fat, crude fibre, protein, and ash from 100 (AOAC, 2005).

Carbohydrate (%) = 100 - (% moisture + % fat + % crude fibre + % protein + % ash) (AOAC, 2016).

➢ *Storage Stability Studies*

The standard and optimized chutney powder formulations were subjected to storage studies to evaluate sensory acceptability and microbiological quality. Organoleptic evaluation was carried out using a nine-point hedonic scale. The samples were stored under ambient conditions (27 ± 2°C and 60–70% relative humidity) for 90 days, and shelf life was assessed based on changes observed in sensory and microbiological parameters throughout the storage period. The standard and optimized brown top millet-incorporated chutney powder samples packed in aluminium foil and PET pouches for storage stability evaluation are shown in *Figure 3*.

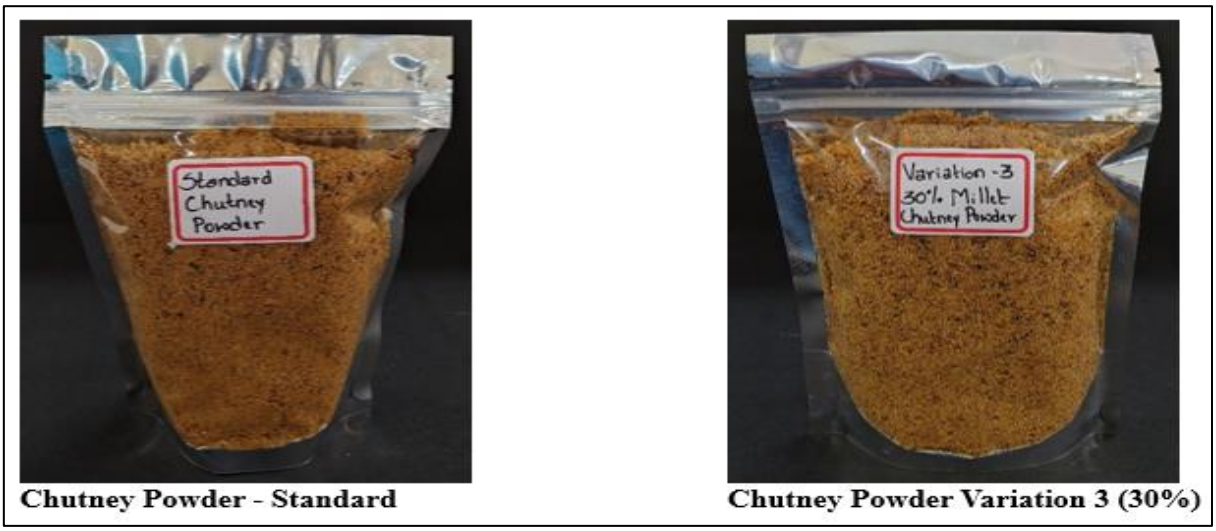


Fig 3 Standard and Optimised Chutney Powder in Aluminum Foil and PET pouch for Storage Studies

➢ *Statistical Analysis of Optimised Chutney Powder*

The experimental results were expressed as mean ± standard error obtained from triplicate determinations. Statistical analysis was performed using appropriate statistical procedures, following the methods described by Gomez and Gomez (1984). This approach facilitated accurate interpretation of the experimental data and identification of differences among the evaluated parameters.

➢ *Cost Analysis of Optimised Chutney Powder*

Economic evaluation of the developed chutney powder was carried out and compared with the standard formulation by accounting for the costs of raw materials, labour, electricity, and packaging materials. Cost analysis is important for assessing the economic viability of the product and provides useful insights for formulation optimization, commercialization, and determination of an appropriate market price (Rai et al. 2017).

III. RESULTS AND DISCUSSIONS

➢ *Development and Sensory Evaluation of Chutney Powder*

Standard chutney powder was prepared by roasting the ingredients separately using oil followed by blending after attaining the room temperature. The prepared chutney powder was seasoned using oil, mustard, urad dhal and asafoetida for added flavour. The proportion of ingredients were mentioned in *Table 1*.

All the formulated variations were found to be sensorially acceptable (*Table 2*); however, the 30% brown top millet (BTM) incorporation level recorded comparatively higher scores for sensory attributes and overall acceptability. The enhanced acceptability of the 30% variation may be due to the optimum balance between millet incorporation and traditional ingredients, resulting in improved flavour, texture, and mouthfeel. Therefore, the 30% BTM incorporated chutney powder is considered optimal for producing the product with enhanced nutritional value without compromising sensory appeal.

Table 2 Sensory Scores of Standard and BTM Incorporated Chutney Powder

Sensory Parameter	Appearance	Colour	Flavour	Taste	Texture	Overall Acceptability
Standard	8.40 ± 0.52	8.30 ± 0.50	8.25 ± 0.54	8.35 ± 0.51	8.45 ± 0.48	8.35 ± 0.50
Variation 1 (20%)	8.10 ± 0.55	8.00 ± 0.58	7.90 ± 0.60	8.00 ± 0.57	8.05 ± 0.56	8.00 ± 0.55
Variation 2 (25%)	7.60 ± 0.60	7.50 ± 0.62	7.40 ± 0.65	7.35 ± 0.68	7.30 ± 0.70	7.25 ± 0.72
Variation 3 (30%)	**8.55 ± 0.50**	**8.60 ± 0.48**	**8.65 ± 0.46**	**8.70 ± 0.45**	**8.75 ± 0.44**	**8.80 ± 0.42**

Values are Expressed as Mean ± SD (n = 30); 9-Point Hedonic Scale

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➢ *Proximate and Nutrient Composition of Chutney Powder*

The incorporation of brown top millet (BTM) into chutney powder formulations significantly enhanced the nutritional quality of the product owing to the nutrient-dense composition of millets (*Table 3*), particularly their dietary fibre, mineral, and bioactive compound contents (Saleh et al. 2013). A slight increase in moisture content was observed in the millet-incorporated variation (3.38 %) compared to the standard formulation (3.11 %), which may be attributed to the higher water absorption capacity and fibre content of brown top millet. However, the moisture level remained within acceptable limits for dry condiment products, thereby supporting product stability during storage.

Table 3 Proximate and Nutrient Composition of Standard and Optimized Chutney Powder per 100g

Parameters	Standard Chutney Powder	Millet Chutney Powder
Moisture (%)	3.11 ± 0.17	3.38 ± 0.2
Protein (g)	18.64 ± 0.68	19.97 ± 0.6
Total Fat (g)	15.90 ± 1.07	15.44 ± 0.92
Carbohydrates (g)	45.89 ± 1.21	44.82 ± 1.34
Ash (g)	5.94 ± 0.22	6.67 ± 0.21
Dietary Fibre (g)	10.52 ± 0.54	13.20 ± 0.51
Energy (Kcal)	422.26 ± 6.4	410.60 ± 5.8
Calcium (mg)	168.3 ± 5.6	178.2 ± 6.0
Magnesium (mg)	144.7 ± 4.2	162.4 ± 5.0
Iron (mg)	5.38 ± 0.24	7.12 ± 0.33
Sodium (mg)	638.4 ± 8.3	832.6 ± 15.4
Thiamine (B1) (mg)	0.23 ± 0.02	0.25 ± 0.02
Riboflavin (B2) (mg)	0.18 ± 0.01	0.19 ± 0.02
β-carotene (µg)	53.8 ± 1.3	61.2± 1.6

Values Represent Mean ± Standard Deviation of Triplicate Determinations (n = 3)

Compared to the standard chutney powder, the BTM-incorporated variation exhibited a reduction in carbohydrate content from 45.89 g to 44.82 g; total fat content from 15.90 g to 15.44 g and protein content by 2.15g per 100 g. Similar reductions in carbohydrate and fat contents following millet incorporation have been reported in millet-based functional food products (Amadou et al. 2013).

A substantial increase in dietary fibre content was observed from 10.52 g to 13.20 g, which may be associated with the inherently high fibre content of millets and their resistant starch fractions (Devi et al. 2014). Increased dietary fibre intake is known to contribute to improved gastrointestinal health and glycaemic regulation (Chandrasekara and Shahidi, 2011). Mineral analysis further revealed enhanced calcium content from 168.3 mg to 178.2 mg and magnesium content from 144.7 mg to 162.4 mg in the BTM-incorporated chutney powder. Iron content also increased significantly from 5.38 mg to 7.12 mg, demonstrating the micronutrient richness of brown top millet, as similarly reported by Rao et al. (2017). Sodium content increased from 638.4 mg to 832.6 mg, which may be attributed to the ingredient composition and seasoning incorporated in the formulation.

Vitamin analysis further indicated marginal improvements in thiamine, riboflavin, and β-carotene contents by 8.70%, 5.56% and 13.75% respectively in the millet-incorporated variation. The enhanced micronutrient profile observed in the developed product supports the potential application of brown top millet in the formulation of nutritionally enriched functional foods (Taylor and Emmambux, 2008).

➢ *Storage Stability Studies*

- *Sensory Acceptability of Chutney Powders During Storage*

The sensory acceptability scores of both the standard and millet-based chutney powders gradually decreased throughout the storage period; however, all samples remained within the acceptable range even after 90 days of storage (*Table 4*). The decline in sensory scores during storage may be attributed to progressive physicochemical and oxidative changes occurring in the product over time, which can influence flavour, colour, and texture characteristics (Manay and Shadaksharaswamy, 2008).

At the initial stage of storage, the millet-based chutney powder exhibited marginally higher scores for appearance, colour, flavour, taste, texture, and overall acceptability compared to the standard formulation. The enhanced sensory quality of the millet-incorporated variation may be associated with the desirable roasted flavour, improved mouthfeel, and characteristic aroma contributed by brown top millet. Similar findings have been reported in millet-based convenience food products where millet incorporation improved organoleptic acceptability without adversely affecting consumer preference (Saleh et al. 2013).

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Table 4 Sensory Acceptability of Standard and BTM Incorporated Chutney Powders During Storage

Storage period (days)	Sample	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
0	Standard	8.9 ± 0.2	8.8 ± 0.2	8.8 ± 0.3	8.8 ± 0.2	8.9 ± 0.2	8.8 ± 0.2
	Variation	9.0 ± 0.1	8.9 ± 0.1	8.9 ± 0.2	8.9 ± 0.2	8.9 ± 0.1	8.9 ± 0.1
15	Standard	8.6 ± 0.3	8.5 ± 0.3	8.5 ± 0.3	8.4 ± 0.3	8.6 ± 0.2	8.5 ± 0.3
	Variation	8.7 ± 0.2	8.6 ± 0.2	8.6 ± 0.2	8.5 ± 0.3	8.7 ± 0.2	8.6± 0.2
30	Standard	8.2 ± 0.4	8.1 ± 0.4	8.0 ± 0.4	7.9 ± 0.4	8.1 ± 0.3	8.0 ± 0.4
	Variation	8.3 ± 0.3	8.2 ± 0.3	8.2 ± 0.3	8.1 ± 0.3	8.3 ± 0.3	8.2 ± 0.3
60	Standard	7.8 ± 0.4	7.6 ± 0.5	7.4 ± 0.5	7.3 ± 0.5	7.8 ± 0.4	7.4 ± 0.4
	Variation	7.9 ± 0.4	7.8 ± 0.4	7.6 ± 0.4	7.5 ± 0.4	7.9 ± 0.3	7.6 ± 0.4
90	Standard	7.2 ± 0.5	7.0 ± 0.5	6.8 ± 0.5	6.7 ± 0.5	7.1 ± 0.5	6.9 ± 0.5
	Variation	7.4 ± 0.4	7.2 ± 0.4	7.1 ± 0.4	7.0 ± 0.4	7.3 ± 0.4	7.1 ± 0.4

Values are Expressed as Mean ± SD, n = 30 Panel Members; 9-Point Hedonic Scale

A gradual reduction in sensory scores was observed with increasing storage duration in both formulations. By the 90th day, the overall acceptability score of the standard chutney powder decreased from 8.8 ± 0.2 to 6.9 ± 0.5, whereas the millet-based variation declined from 8.9 ± 0.1 to 7.1 ± 0.4. Despite this decline, the millet-based variation consistently maintained slightly higher sensory scores throughout the storage period. The reduction in flavour and taste scores during storage could be attributed to lipid oxidation and volatilization of flavour compounds, which are common phenomena in spice- and oil-containing food products (Kumar et al. 2018). Nevertheless, the overall acceptability scores remained above the acceptable sensory threshold, indicating satisfactory shelf stability of the developed product.

- *Microbiological Quality Analysis During Storage*

The microbiological quality of the standard and millet-based chutney powders was evaluated periodically during 90 days of ambient storage to assess product safety and shelf stability (*Table 5*). The results indicated that both formulations maintained satisfactory microbiological quality throughout the storage period, with microbial counts remaining within acceptable permissible limits for dry food products. Similar observations have been reported in low-moisture traditional food products, where reduced water activity restricts microbial proliferation during storage (Frazier & Westhoff, 2004).

Total bacterial count (TBC) and total plate count (TPC) were not detected in both formulations up to 30 days of storage, indicating good hygienic manufacturing practices and minimal initial microbial contamination. A gradual increase in microbial load was observed after 60 days of storage, which may be attributed to slight moisture absorption and environmental exposure during storage conditions. At the end of the storage period, the standard chutney powder exhibited TBC and TPC values of 1.8×10^2 cfu/g and 1.5×10^2 cfu/g, respectively, whereas the millet-based variation recorded comparatively lower counts of 1.4×10^2 cfu/g and 1.1×10^2 cfu/g. The lower microbial load observed in the millet-incorporated variation may be associated with the presence of phenolic compounds and natural antioxidants in brown top millet, which are reported to possess antimicrobial activity (Chandrasekara & Shahidi, 2011).

Table 5 Microbiological Quality of Standard and BTM Incorporated Chutney Powder During Storage

Sl. No.	Sample type	Test attributes	Initial/ Day 0	Day 15	Day 30	Day 60	Day 90
	Standard	TBC (cfu/g)	ND	ND	ND	6.2×10^1	1.8×10^2
	Variation	TBC (cfu/g)	ND	ND	ND	5.4×10^1	1.4×10^2
	Standard	TPC (cfu/g)	ND	ND	ND	5.0×10^1	1.5×10^2
	Variation	TPC (cfu/g)	ND	ND	ND	4.2×10^1	1.1×10^2
	Standard & Variation	Yeast & Mold count cfu/g	<10	<10	<10	<10	<10
		Coliforms, cfu/g	<10	<10	<10	<10	<10
		E. Coli, /g	<10	<10	<10	<10	<10
		Salmonella / 25g	Absent	Absent	Absent	Absent	Absent
		Staphylococcus aureus, /g	Absent	Absent	Absent	Absent	Absent
		Listeria monocytogenes, /25g	Absent	Absent	Absent	Absent	Absent
	*ND – Not Detected *Total bacterial Count- TBC *Total Plate Count- TPC						

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Yeast and mold counts remained below detectable levels (<10 cfu/g) throughout the storage period in both formulations, suggesting good storage stability and low susceptibility to fungal spoilage. The absence of fungal growth may also be attributed to the low moisture content of the product, which limits microbial growth and enzymatic activity (Jay et al. 2005).

Furthermore, coliforms, *Escherichia coli*, *Salmonella*, *Staphylococcus aureus*, and *Listeria monocytogenes* were absent throughout the storage period, confirming the microbiological safety and hygienic quality of the developed chutney powders. The absence of pathogenic microorganisms indicates that the processing, handling, and packaging conditions adopted during product preparation were satisfactory and complied with food safety standards. Similar findings have been reported in spice- and millet-based dry convenience foods stored under ambient conditions (Saleh et al. 2013).

Overall, the microbiological results demonstrated that both the standard and millet-based chutney powders remained microbiologically safe and shelf-stable for up to 90 days under ambient storage conditions, with the millet-based variation exhibiting comparatively better microbial stability.

➢ *Cost Analysis of Chutney Powder*

The economic feasibility of the developed brown top millet (BTM)-incorporated chutney powder was assessed and compared with the standard formulation (*Table 6*). Cost analysis revealed that the total production cost of the BTM-incorporated chutney powder was comparatively higher (Rs. 51.37 per 100 g; Rs. 513.7 per kg) than the standard chutney powder (Rs. 43.66 per 100 g; Rs. 436.6 per kg). The increased production cost of the millet-based variation was primarily attributed to the higher market price of dehulled brown top millet, which contributed Rs. 12.76 to the total formulation cost. Similar observations have been reported in millet-based value-added products where incorporation of specialty millets and functional ingredients increased the overall production cost due to limited commercial availability and higher processing expenses (Rai et al. 2017).

Table 6 Cost Analysis of Standard and BTM Incorporated Chutney Powder

Ingredients	Market Price/ kg (Rs.)	Standard Chutney Powder Ingredients Quantity (g)	Price (Rs.)	BTM Incorporated Chutney Powder Ingredients Quantity (g)	Price (Rs.)
Channa Dhal (g)	140	56	7.84	39.2	5.48
Urad Dhal (g)	160	61	9.76	44.2	7.07
Brown top Millet (Dehulled) (g)	380	0	0	33.6	12.76
Copra (g)	240	20	4.8	20	4.8
Oil (ml)	160	15	2.4	15	2.4
Red Chillies Byadagi (g) Guntur (g)	400 190	10 8	04 1.52	10 8	04 1.52
Tamarind Powder (g)	400	7	2.8	7	2.8
Jaggery Powder (g)	90	6	0.54	6	0.54
Mustard seeds (g)	80	2.5	Negligible	2.5	Negligible
Asafoetida (g)	1200	1.5	Negligible	1.5	Negligible
Salt (%)	25	2	Negligible	2	Negligible
Production charges [Includes- Processing, Electricity, Labour wages, Packaging material			10		10
Total cost of chutney powder per 100 in Rs.			**43.66**		**51.37**
Total cost of chutney powder per Kg in Rs.			**436.6**		**513.7**

Despite the comparatively higher cost, the developed BTM-incorporated chutney powder demonstrated superior nutritional quality with enhanced dietary fibre, mineral, and micronutrient composition, thereby justifying its economic value as a functional food product. The incorporation of brown top millet improved protein, dietary fibre, calcium, magnesium, iron, and vitamin contents, indicating its potential application as a nutrient-dense convenience food. Previous studies have also emphasized that millet-based functional foods provide added nutritional and health benefits that compensate for the slightly increased production cost (Saleh et al. 2013).

The major cost components in both formulations were contributed by pulse ingredients, red chillies, copra, and processing charges including labour, electricity, and packaging materials. Although brown top millet increased the formulation cost, the product remained economically feasible for commercialization considering its enhanced nutritional profile and shelf stability. Similar findings have been reported for millet-incorporated traditional food products, where

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improved nutritional functionality and consumer demand for health-oriented foods supported market acceptance despite higher ingredient costs (Muthamilarasan & Prasad, 2021).

Furthermore, increasing consumer awareness regarding healthy dietary practices and millet-based foods may improve the commercial viability of such value-added products. The developed BTM chutney powder therefore represents a promising functional convenience food with potential economic and nutritional benefits for both consumers and food industries.

IV. SUMMARY

The present investigation focused on the development and evaluation of value-added chutney powder incorporated with brown top millet (*Brachiaria ramosa*) as a functional ingredient. Three variations containing 20%, 25%, and 30% brown top millet were developed by partially replacing channa dhal and urad dhal in the standard formulation. Sensory evaluation of the developed products revealed that all the formulations were organoleptically acceptable; however, the 30% brown top millet-incorporated variation exhibited comparatively higher scores for appearance, colour, flavour, taste, texture, and overall acceptability. The improved sensory quality of the optimized variation may be attributed to the balanced incorporation of millet with traditional ingredients, resulting in desirable flavour and mouthfeel characteristics.

Proximate and nutrient composition analysis demonstrated that incorporation of brown top millet significantly enhanced the nutritional profile of the chutney powder. The millet-based variation showed increased dietary fibre, ash, calcium, magnesium, iron, thiamine, riboflavin, and β-carotene contents compared to the standard formulation. A slight reduction in carbohydrate, protein, fat, and energy values was also observed in the optimized product. These improvements indicate the nutritional potential of brown top millet in enhancing the functional quality of traditional convenience foods.

Storage stability studies conducted under ambient conditions (27 ± 2°C and 60–70% relative humidity) for 90 days revealed gradual reductions in sensory scores in both formulations; however, the products remained within acceptable sensory limits throughout the storage period. The millet-based variation consistently maintained slightly higher acceptability scores compared to the standard formulation. Microbiological analysis indicated that total bacterial count and total plate count remained within permissible limits during storage, while yeast and mold counts remained below detectable levels. Pathogenic microorganisms including *Escherichia coli*, *Salmonella*, *Staphylococcus aureus*, and *Listeria monocytogenes* were absent throughout the storage period, confirming the microbiological safety of the developed product.

Economic evaluation further demonstrated that the developed millet-based chutney powder was economically feasible and suitable for commercialization as a nutritious convenience food product.

V. CONCLUSION

The findings of the present study demonstrated that brown top millet (*Brachiaria ramosa*) can be successfully utilized for the development of nutritionally enriched chutney powder with good sensory acceptability and storage stability. Incorporation of brown top millet at 30% level resulted in improved dietary fibre, mineral, and vitamin contents without adversely affecting organoleptic quality. The developed millet-based chutney powder also exhibited satisfactory microbiological safety and shelf stability for up to 90 days under ambient storage conditions.

The study highlights the potential of brown top millet as a functional ingredient for value addition in traditional food products and supports its utilization in the development of health-oriented convenience foods. Promotion of millet-based products may contribute towards dietary diversification, improved nutritional security, and increased utilization of underexploited millets. The developed chutney powder therefore offers a promising, nutrient-dense, shelf-stable, and consumer-acceptable functional food product with potential commercial application.

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