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Effect of *Boerhaavia diffusa* (*Punarnava*) leaves addition on the Nutritional and Sensory Properties of *chutney*

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Abstract
The growing demand for functional foods has encouraged the exploration of nutritionally rich plant-based ingredients for incorporation into traditional foods. The present study aimed to develop value-added *chutney* enriched with *Boerhaavia diffusa* (*Punarnava*) leaves and to evaluate its sensory acceptability and nutritional composition. *Chutney* was formulated by incorporating *Punarnava* leaves at 20 per cent, 40 per cent, and 60 per cent levels, along with a control sample. The developed samples were assessed for organoleptic attributes using a nine-point hedonic scale, while proximate, mineral, and vitamin analyses were carried out using standard analytical methods.
The results indicated that incorporation of *Punarnava* leaves improved the sensory quality of *chutney*, with the 40 per cent level (type II) receiving the highest overall acceptability score among the supplemented treatments. Nutritional analysis revealed a decrease in moisture content and a notable increase in crude fibre and ash content, indicating enhanced dietary fibre and mineral content. Furthermore, the supplemented sample exhibited substantial improvements in mineral composition, including iron, zinc and calcium, along with a marked increase in ascorbic acid and β-carotene content.
In conclusion, incorporation of *Boerhaavia diffusa* leaves up to 40 per cent resulted in a nutritionally enriched and sensory acceptable *chutney*. The study highlights the potential of *Punarnava* as a functional ingredient for the development of health-promoting products, offering a sustainable approach to improving dietary quality and utilization of underexploited medicinal plants.

Keywords: *Boerhaavia diffusa, Punarnava, chutney*, sensory evaluation, nutritional composition

Introduction
Medicinal plants have been recognised as valuable sources of different bioactive compounds with significant nutritional and therapeutic potential. The increasing consumer demand for functional foods has driven the exploration of plant- based ingredients with nutritional and health benefits. *Boerhaavia diffusa*, commonly known as *Sathi* or *Punarnava*, is one such plant which holds a prominent place in traditional systems of medicine, particularly in Ayurveda. It belongs to *Nyctaginaceae* family. In Ayurveda it is referred to as a *Punarnava* due to its rejuvenating and restorative properties. The plant is valued for its ability to revive itself seasonally and for its role in promoting vitality and overall health.
Punarnava is a perennial, creeping herb distributed extensively across tropical and subtropical regions, including India, Australia, Sri Lanka, Africa and different parts of Asia (Chaudhary and Dantu, 2011 [1]; Nayak and Thirunavoukkarasu, 2016) [2]. Almost all the parts of plant, including roots, leaves, seeds have been traditionally used to treat various ailments such as liver disorders, kidney dysfunction, inflammation, anaemia, jaundice and various kinds of skin diseases (Prajapati *et al.*, 2004) [3].
Scientific studies have attributed these health benefits due to the presence of different phytochemicals such as alkaloids, flavonoids, glycosides, steroids, tannins, terpenoids and phenolic compounds (Shisode and Kareppa 2011 [4], Krishnamoorthey *et al.*, 2017) [5]. These bioactive constituents contribute to its diverse pharmacological activities, including antidiabetic, antioxidant (Dhara *et al.*, 2011) [6], antibacterial (Olukoya *et al.*, 1993) [7], diuretic (Gaitonde *et* al., 1974) [8], hepatoprotective (Chakraborti and Handa.,1989) [9] anticancer (Khan *et al.*, 2013) [10], renoprotective, cardioprotective, anti-inflammatory (Bhalla *et al.*,1971) [11] and immunomodulatory.

In addition to its medicinal importance, *Boerhaavia diffusa* also possesses notable nutritional value. Its leaves are edible and are also consumed as a vegetable in certain regions of India (Jana, 2007) [12], providing essential nutrients such as proteins, vitamins (particularly Vitamin C and B-complexes) and minerals including iron, calcium, sodium, potassium, zinc, magnesium (SP Moulick *et al*.,2024) [13].The edible leaves of Punarnava possess considerable nutritional potential and can be incorporated into traditional food formulations for development of functional foods.

Given its dual role as a nutritionally rich and pharmacologically active plant, *Punarnava* show significant potential for incorporation into functional food products. The development and evaluation of such products can provide sustainable approach to enhancing dietary quality while delivering health benefits.

Chutney, a traditional Indian condiment, is widely consumed throughout India due to its unique flavour, palatability and ability to complement a variety of foods. In addition to enhancing taste, *chutney* can serve as an effective medium for the incorporation of nutritionally rich herbal ingredients. Despite its popularity, limited research is available regarding the utilisation of fresh leaves of *Punarnava* in *chutney* formulations, particularly with respect to their effects on sensory acceptability and nutritional enhancement. Therefore, present study aims to develop *chutney* by utilising fresh leaves of *Punarnava* and to evaluate its organoleptic attributes and nutritional composition. This approach seeks to combine traditional knowledge with modern food innovation to develop a functional beverage with potential health promoting benefits.

Fig 1: *Boerhaavia diffusa* Leaves

Research Methodology

The study was designed to explore the utilisation of fresh leaves of *Boerhaavia diffusa* in the development of value-added *chutney*. An experimental framework was adopted involving the preparation of formulations with incremental incorporation levels (20%, 40% and 60%), along with a control sample. The effect of these varying incorporation levels on the nutritional and sensory attributes of the *chutney* was systematically evaluated.

Procurement of raw materials

Leaves of *Punarnava* were collected from Rohtak, Haryana. All other ingredients required for preparation of value-added *chutney* were procured from the local market in Rohtak. The experimental work was conducted in the Department of Food and Nutrition, Institute of Higher Learning, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan, Sonepat.

Processing of *Boerhaavia diffusa* leaves

Fresh leaves of *Punarnava* were thoroughly washed under running tap water to remove adhering soil, dirt, dust and extraneous matter.

Development of value –added *chutney* by using *Boerhaavia diffusa* leaves

Value-added *chutney* was developed by incorporating *Punarnava* leaves at varying levels. Four formulations were prepared- control (without supplementation) and three experimental variations containing 20%, 40% and 60% *Punarnava* leaves, designated as type I, type II and type III respectively. The incorporation was achieved by partially substituting coriander leaves with fresh Punarnava leaves in the respective proportions. This standardised formulation approach enabled evaluation of the effect of graded levels of *Punarnava* leaves on the sensory attributes of the developed *chutney*.

Table 1: Experimental Design for Control and other treatments of *chutney*

	Types of *Chutney*			
Ingredients	**Control**	**Type I**	**Type II**	**Type III**
Coriander leaves (g)	100	80	60	40
Punarnava leaves (g)	-	20	40	60
Onion (g)	10	10	10	10
Tomato (g)	10	10	10	10
Green chilli (g)	3	3	3	3
Salt (g)	2	2	2	2
Lemon juice (g)	2	2	2	2

Method

- Finely chop cleaned and washed fresh leaves.
- Add all the ingredients in a mixer grinder jar in measured quantities.
- Add small amount of water to obtain the desired consistency.
- Grind it well into a smooth chutney paste.
- Add lemon juice in the end and serve.

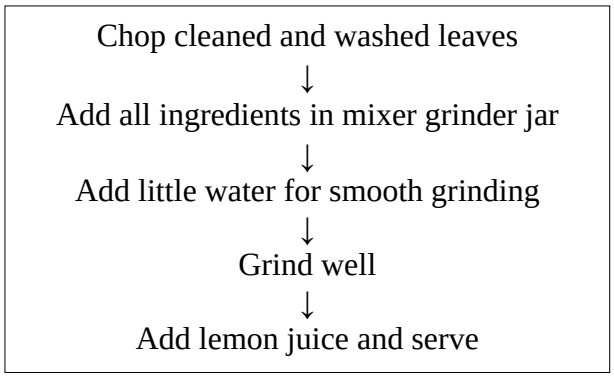

Fig 2: Flow diagram of *chutney* preparation

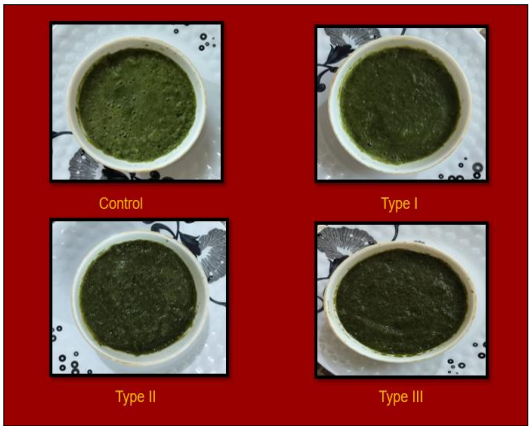

Fig 3: *Punarnava chutney*

Control: 100% Coriander leaves

- **Type I:** 80 % Coriander leaves + 20% *Boerhaavia diffusa* leaves
- **Type II:** 60% Coriander leaves + 40% *Boerhaavia diffusa* leaves
- **Type III:** 40% Coriander leaves + 60% *Boerhaavia diffusa* leaves

Organoleptic analysis of value – added *chutney*

The developed products were subjected to sensory evaluation for attributes including colour, appearance, aroma, texture, taste, and overall acceptability using a nine-point hedonic scale. On this scale, a score of 9 corresponded to "like extremely," while a score of 1 indicated "dislike extremely." The mean scores obtained for individual sensory attributes were used to determine overall acceptability. Panel members were instructed to rinse their mouths with water before and between the evaluation of each sample to minimize carryover effects and ensure unbiased assessment.

Nutritional analysis of developed products

Parameters of proximate analysis and vitamin estimation was done by standard method (AOAC,2010). Minerals were assessed through acid digestion followed by atomic absorption spectrophotometry (Lindsey and Norwell,1969).

Results and Discussion

Value-added *chutney* prepared using variable percentage of *Boerhaavia diffusa* (*Punarnava*) leaves was evaluated at various parameters for its acceptance and nutritional analysis.

Organoleptic evaluation of *Chutney*

The organoleptic evaluation of *chutney* incorporated with *Punarnava* leaves was conducted to determine the sensory acceptability of developed formulation. The sensory parameters evaluated included colour, appearance, aroma, texture, taste and overall acceptability. The mean sensory scores indicated that all the supplemented samples were well accepted, with scores falling the range of "like moderately" to "like very much" on the nine-point hedonic scale, demonstrating the feasibility of incorporating *Punarnava* leaves into *chutney* without compromising acceptability.

The colour scores of the developed *chutney* ranged from 8.1±0.87 to 8.5 ± 0.52. The control sample scored highest for colour whereas a gradual decline in colour scores was observed with increasing incorporation level of *Punarnava* leaves. Nevertheless, the variations among the treatments were statistically non- significant, indicating that the incorporation of *Punarnava* leaves did not markedly influence the visual appeal of the product.

The appearance scores varied between 8.0 ±0.81 and 8.5±0.52. The control and type I (20 per cent) formulation) exhibited comparatively higher appearance scores than type III (per cent) which scored relatively lower. The reduction in appearance scores at higher incorporation may be attributed to the increased intensity of green pigmentation and changes in consistency associated with the addition of larger quantity of fresh *Punarnava* leaves.

The aroma scores ranged from 8.1 ± 0.31 to 8.5±0.52. Among the supplemented treatments, type II (40 per cent) *chutney* obtained the higher aroma scores, although differences among treatments were statistically non-significant. The texture scores ranged from 7.9±0.87 to 8.4±0.51. Type II (40 per cent) supplementation received the highest texture score, indicating desirable consistency and mouthfeel. A slight decline in texture acceptability was observed at higher incorporation levels, which is due to the fibrous nature of fresh *Punarnava* leaves affecting the smoothness and uniformity of the *chutney.*

Taste scores ranged between 7.6 ±0.69 to 8.5 ±0.70. The control sample obtained the highest taste score, whereas a progressive decline in taste was observed with increasing incorporation levels of *Punarnava* leaves. This reduction may be attributed mild bitter flavour with higher level of incorporation. However, all the supplemented formulations remained within the acceptable sensory range.

The overall acceptability scores of *chutney* samples ranged from 7.98 ±0.72 to 8.38±033. Among the supplemented treatments, type II formulation containing 40 per cent fresh *Punarnava* leaves exhibited the highest overall acceptability and was considered the most desirable formulation. Although, overall acceptability of type III (60 per cent) recorded comparatively lower than other but still it was found to be organoleptically acceptable.

The findings of the present investigation indicate that fresh leaves of *Punarnava* can be effectively incorporated into *chutney* formulations up to 40 per cent level without adversely affecting sensory quality and consumer acceptability. The developed product may therefore serve as a promising functional food with enhanced nutritional and therapeutic potential.

Table 2: Mean sensory scores of sensory attributes of *Punarnava* leaves added *chutney*

Samples	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
Control	8.5±0.52[a]	8.5±0.52 [a]	8.1±0.31 [a]	8.3±0.48 [a]	8.5±0.70 [a]	8.38±0.33 [a]
Type I (20%)	8.4±0.51 [a]	8.5±0.52 [a]	8.1±0.31 [a]	8.3±0.48 [a]	8.1±0.31 [ab]	8.28±0.23 [a]
Type II (40%)	8.3±0.48 [a]	8.4±0.51 [a]	8.5±0.52 [a]	8.4±0.51 [a]	7.9±0.73 [b]	8.30±0.21 [a]
Type III (60%)	8.1±0.87 [a]	8.0±0.81 [a]	8.3±0.94 [a]	7.9±0.87 [a]	7.6±0.69 [b]	7.98±0.72 [a]
CD (p≤0.05)	0.56	0.55	0.53	0.56	0.58	0.39

Values are Mean ± SD of three independent determinations

Control: 100% Coriander Leaves

- **Type I:** 80% Coriander Leaves + 20% *Boerhaavia diffusa* leaves
- **Type II:** 60% Coriander leaves + 40% *Boerhaavia diffusa* leaves
- **Type III:** 40% Coriander leaves + 60% *Boerhaavia diffusa* leaves

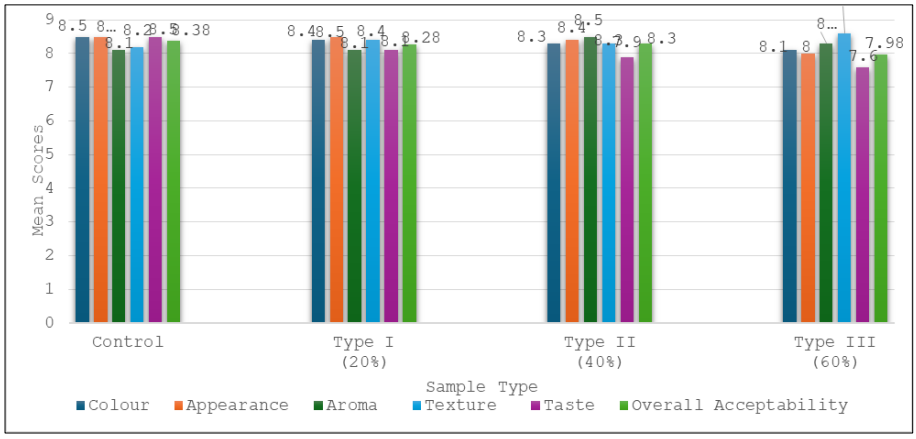

Fig 4: Mean scores of sensory attributes of *Punarnava* Leaves value added *chutney*

Nutritional analysis of *Chutney*

Nutritional analysis of control and most organoleptically acceptable *chutney* was done to access the impact of incorporation of fresh *Punarnava* leaves on the nutrient profile of the product. Values were expressed per 100 g of the sample. Statistical analysis was performed and three differences among treatments were evaluated at $p \leq 0.05$ level of significance.

Proximate Analysis

Table 3: Proximate Analysis (per 100 g) of Control and Type II (40%) *Punarnava* Leaves *chutney*

Samples	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)
Control	82.25±0.42[a]	1.45±0.22[a]	0.50±0.17[a]	2.25±0.30[a]	1.45±0.24[a]
Type II (40%)	81.62±0.20[b]	3.71±0.30[b]	0.65±0.25[b]	2.78±0.35[b]	1.64±0.21[b]

Values are Mean ± SD of three independent determinations.

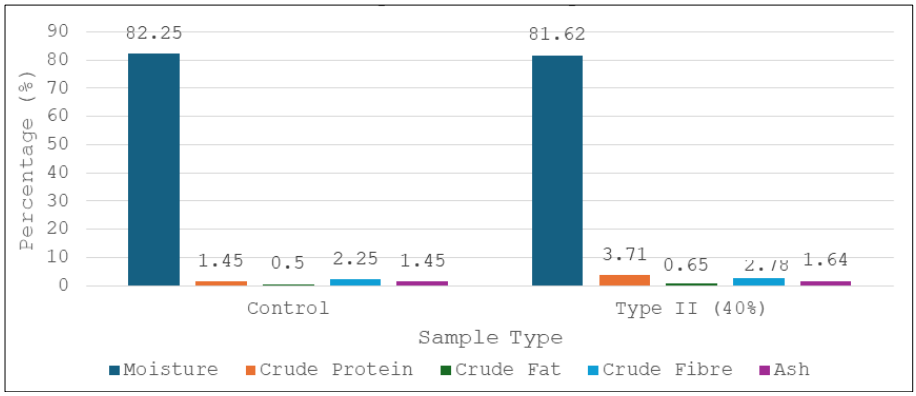

Fig 5: Proximate Analysis of *Chutney*

The proximate composition of developed *chutney* incorporated with *Punarnava* leaves (40%) exhibited notable differences when compared to the control sample, indicating an overall improvement in nutritional quality.

Moisture

The moisture content of the developed *chutney* decreased significantly ($p \leq 0.05$) from 82.25 per cent in the control sample to 81.62 per cent in the Type II formulation. This reduction may be attributed to the incorporation of fresh leaves of *Boerhaavia diffusa*, which contributed comparatively lower moisture and altered the overall solid composition of the product. The observed decline in moisture content indicates an increase in total solids in the supplemented *chutney* formulation.

Crude Protein

A statistically significant increase ($p \leq 0.05$) in crude protein content was observed following incorporation of fresh *Boerhaavia diffusa* leaves into the *chutney*. The protein content increased markedly from 1.45 per cent in the control sample to 3.7 per cent in the type II formulation. This enhancement in protein level may be attributed to the inherent protein content of *Punarnava* leaves, thereby improving the nutritional quality of the developed product.

Crude Fat

The crude fat content of the supplemented chutney also exhibited a significant increase ($p \leq 0.05$), rising from control (0.50 per cent) to (0.65 per cent) in the type II formulation. The increase in fat content may be associated with the

natural lipid constituents present in the fresh *Punarnava* leaves incorporated into the product.

Crude Fibre

The crude fibre content increased significantly ($p \leq 0.05$) from 2.25 per cent in the control sample to 2.78 per cent in the supplemented *chutney*. The enhancement in fibre content may be attributed to the fibrous nature of fresh *Boerhaavia diffusa* leaves. Increased dietary fibre content enhances the functional and nutritional value of the developed *chutney* and may contribute beneficial physiological effects.

Ash

Ash content, which represents the total mineral matter present in the product, showed a statistically significant increase ($p \leq 0.05$) from control (1.45 per cent) to (1.64 per cent) in type II formulation. The increase in ash content indicates improved mineral composition of the supplemented *chutney*, which may be attributed to the mineral-rich nature of fresh *Boerhaavia diffusa* leaves.

Therefore, the incorporation of *Punarnava* leaves in *chutney* enhanced the protein, fibre, ash, contents of the developed product. These findings support its potential application as a functional ingredient for the development of nutritionally enriched traditional *chutney* and other products. The present findings are in accordance with previous investigations which reported that incorporation of herbal and green leafy plant materials into traditional food formulations significantly enhanced dietary fibre, mineral, and micronutrient content (Penalver, R *et al*.,2022) [14] thereby improving the overall nutritional and functional quality of the developed products.

Table 4: Mineral Composition (per 100 g) of Control and Type II (40%) *Punarnava* leaves *chutney*

Sample	Iron (mg)	Magnesium (mg)	Zinc (mg)	Calcium (mg)
Control	3.26±0.20[a]	31.20±0.65[a]	0.50±0.21[a]	64.28±0.84[a]
Type II (40%)	3.74±0.32[b]	24.65±0.55[b]	0.65±0.14[b]	120.63±0.97[b]

Values are Mean ± SD of three independent determinations

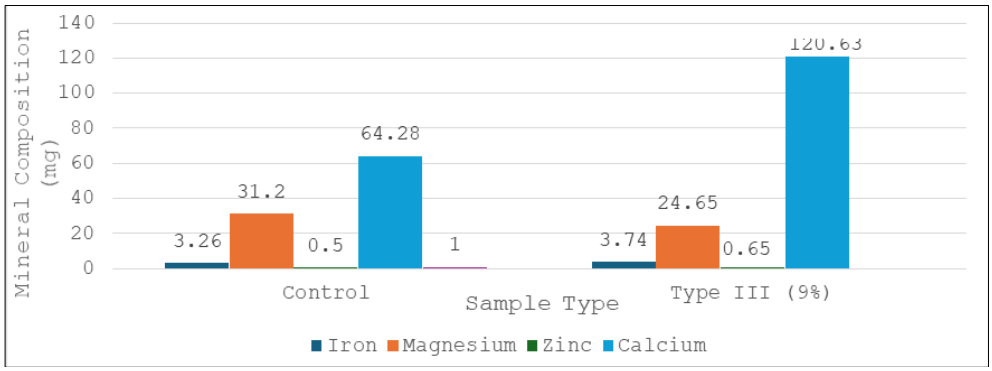

Fig 6: Mineral Composition (per 100g) of *Chutney*

The incorporation of *Boerhaavia diffusa* leaves at 40% level resulted in a marked enhancement in the mineral composition of *chutney*.

Iron

The iron content of the developed *chutney* increased significantly ($p \leq 0.05$) from 3.26 mg in control to 3.74 mg in type II (40%) *chutney*. The increase in iron content demonstrates the mineral rich nature of *Punarnava* leaves which indicates its potential in addressing micronutrient deficiency.

Magnesium

The magnesium content decreased significantly ($p \leq 0.05$) from 31.20 mg in the control to 24.65 mg in type II in which 40% *Punarnava* leaves was added. The reduction in magnesium content may be attributed to compositional variations resulting from ingredient substitution.

A significant increase ($p \leq 0.05$) in zinc content was observed after incorporation of *Boerhaavia diffusa* leaves. The zinc content increased to 0.65 mg in type II (40%) sample from control sample i.e. 0.50 mg. The enhanced zinc content reflects the contribution of *Punarnava* leaves towards improving micronutrient profile of the product which play important roles in metabolic functions, immune response and overall physiological health.

Calcium

A pronounced increase was also recorded in the calcium content of value- added *chutney*. The calcium content significantly increased ($p \leq 0.05$) from 64.28 mg in control to 120.63 mg in type II (40%) sample. This increase proves that *Boerhaavia diffusa* leaves is a valuable source of calcium which is particularly beneficial for bone health and structural functions in the body.

Overall, the results demonstrate that the incorporation of *Boerhaavia diffusa* leaves effectively improves the micronutrient density of *chutney*, supporting its use as a functional ingredient in the development of nutritionally enriched product. The present findings are in agreement with earlier studies which reported that green leafy vegetables are valuable sources of essential minerals, thereby contributing significantly towards improvement of micronutrient composition in food products (Khader V. *et al*., 1998) [15].

Table 5: Vitamin Composition (per 100g) of Control and Type II (40%) *Punarnava* leaves *chutney*

Sample	Ascorbic acid (mg)	β- carotene (µg)
Control	25.02±0.45	3262.87±0.87
Type II (40%)	29.89±0.91	3356.41±0.99

Values are Mean ± SD of three independent determinations

The vitamin composition analysis revealed a significant enhancement in both ascorbic acid and β-carotene content following the incorporation of *Punarnava* leaves into *chutney*.

Ascorbic acid

A substantial increase in ascorbic acid content was observed in the supplemented sample (29.89 mg) compared to the control (25.02 mg). This marked improvement can be attributed to the naturally high vitamin C content of *Punarnava* leaves. The enrichment of ascorbic acid enhances the antioxidant potential of this value- added product and contributes to improved immune function and overall health benefits.

β-carotene

Similarly, the β-carotene content showed an increase from 3262.87 µg in the control to 3356.41 µg in the type II sample. β-carotene, a precursor of vitam in A, plays a crucial role in vision, skin health, and antioxidant activity. Although the increase is moderate, it still indicates the contribution of plant-based carotenoids from the fresh leaves. Overall, the incorporation of *Boerhaavia diffusa* leaves at 40% significantly improved the vitamin profile of *chutney*, particularly enhancing its antioxidant capacity. Previous investigations have also demonstrated that green leafy vegetables are rich sources of β-carotene and ascorbic acid, contributing significantly to antioxidant potential and nutritional quality (Singh G. *et al*., 2001) [16]. These findings support the potential of *Punarnava* as a functional ingredient for developing nutritionally enriched value-added product with added health benefits.

Conclusion

The present investigation successfully demonstrated the potential of fresh leaves of *Boerhaavia diffusa* for incorporation into value-added *chutney* as a functional food ingredient possessing considerable nutritional significance. The incorporation of *Punarnava* leaves exerted a marked influence on both the sensory and nutritional attributes of the developed product. Among the various formulations, the Type II formulation containing 40 per cent *Punarnava* leaves emerged as the most acceptable in terms of colour, appearance, aroma, texture, taste and overall acceptability, thereby indicating an optimum balance between palatability and nutritional enhancement. Although marginal declines in certain sensory characteristics were observed at higher supplementation levels, all formulations remained within the acceptable sensory range.

Nutritional evaluation of the developed chutney revealed significant improvements in protein, crude fibre, ash, mineral, and vitamin contents following incorporation of *Punarnava* leaves. The supplemented formulation exhibited appreciable increases in iron, zinc, calcium, ascorbic acid, and β-carotene content, thereby reflecting the rich nutritional profile of *Punarnava* leaves and their potential contribution towards improving micronutrient intake and overall dietary quality. The enhancement in fibre and mineral content further underscores the functional and health-promoting potential of the developed product.

The findings of the present study are in consonance with earlier investigations which have highlighted the nutritional and functional merits of incorporating medicinal and green leafy plant materials into traditional food systems. The study therefore emphasises the scope for utilisation of underexploited medicinal plants such as *Boerhaavia diffusa* in the formulation of nutritionally enriched and health-promoting food products. Incorporation of *Punarnava* leaves into traditional preparations may serve as a sustainable and economical approach towards enhancement of dietary diversity, nutritional security, and consumer well-being. Furthermore, future research pertaining to phytochemical profiling, antioxidant potential, shelf-life stability, and large-scale consumer acceptability may provide greater insight into the commercial applicability and functional efficacy of *Punarnava*-based food products.

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