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DEVELOPMENT OF A NATURAL SPICE-BASED HERBAL POWDER FORTIFIED WITH MYROBALAN AND TURMERIC: FORMULATION, SENSORY EVALUATION AND ANTIOXIDANT PROFILING

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ABSTRACT

Herbs and spices such as black pepper, dried ginger, long pepper and cinnamon have been valued in Ayurveda for their antioxidant, digestive and bio-enhancing properties. In this study, a natural spice-based herbal powder was developed using these four spices as a constant base, with Myrobalan and turmeric incorporated at two increasing levels to obtain Variation I and Variation II. Twenty semi-trained panellists evaluated the products for appearance, colour, taste, texture, aroma and overall acceptability using a 5-point hedonic scale. The basic recipe scored highest for taste, texture, aroma and overall acceptability, while Variation I scored highest for appearance; one-way ANOVA showed no significant difference among the three formulations (F-calculated = 2.24 < F-table = 3.16, p = 0.116). Nutrient calculation showed a progressive rise in energy, carbohydrate, fat and polyphenol content from Basic to Variation II, with a slight decline in protein and fibre. Laboratory analysis of the Basic and Variation I samples revealed markedly higher total polyphenolic content (2150 vs 2980 mg/100 g) and antioxidant activity (75% vs 87%) in Variation I, confirming that fortification enhanced the functional properties of the product. The developed spice-based herbal powder was sensorially acceptable and nutritionally beneficial.

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INTRODUCTION

Herbs and spices have been used since ancient times for their medicinal, nutritional and therapeutic properties, being rich sources of bioactive compounds such as polyphenols, flavonoids, alkaloids and essential oils that contribute to antioxidant, antimicrobial, anti-inflammatory and immune-enhancing effects (Al-Habsi *et al*., 2025). Increasing awareness of the adverse effects of synthetic additives and medicines has fuelled interest in natural, functional food products formulated from such ingredients, particularly as an accessible route to supporting immune function against poor dietary habits, pollution, stress and sedentary lifestyles. The concept of enhancing bioavailability originated in Ayurveda, which has for centuries employed bio-enhancers such as Piper longum, Zingiber officinale, cinnamon and Piper nigrum to potentiate the biological activity of co-administered drugs at low doses, thereby reducing therapeutic dose, toxicity and cost. Among these, black pepper (Piper nigrum) contains piperine, which enhances nutrient absorption and possesses antioxidant activity; dried ginger (Zingiber officinale) is valued for digestive, anti-inflammatory and antimicrobial action; long pepper (Piper longum) supports immunomodulatory and respiratory health; and cinnamon (Cinnamomum verum) exhibits antioxidant and blood-glucose-regulating properties. Myrobalan (Terminalia chebula) is rich in phenolic compounds and is traditionally used for digestive health and detoxification, while turmeric (Curcuma longa) contains curcumin, a potent antioxidant and anti-inflammatory compound with well-documented health benefits. Cardioprotective reviews of Indian spices report that garlic, turmeric, ginger, black pepper, cinnamon and coriander act through antioxidant, hypolipidemic, antiplatelet and antihypertensive mechanisms to reduce cardiovascular risk (Vasanthi and Parameswari, 2010), while broader reviews of culinary spices highlight antioxidant, anti-inflammatory, antimicrobial and anti-carcinogenic activities linked to compounds such as curcumin, gingerol and piperine (Spence, 2025). The classical Ayurvedic formulation TrikatuChurna, composed of equal parts Maricha, Pippali and Shunthi, is well documented for piperine-mediated bioavailability enhancement, hypolipidemic, hepatoprotective and antioxidant effects (Sharma *et al*., 2024), underscoring the rationale for combining pungent spices as a bio-enhancing base. Herbal powders, teas and confectionery fortified with spices have been widely explored as delivery formats. Multi-herbal-powder-incorporated teas have shown measurably higher antioxidant and functional potential than single-ingredient preparations (Aariba and Raman, 2025), cinnamon-palm-sugar herbal drink powders have demonstrated concentration-dependent gains in flavonoid, phenolic and antioxidant activity together with good sensory acceptance (Ginitri and Agung, 2025), and reviews of herb- and spice-fortified confectionery report simultaneous improvements in bioactive content and consumer acceptability when additive levels are optimised (Ishchenko and Złotek, 2025). Poly-herbal tea blends of Hibiscus sabdariffa, Moringa oleifera, Zingiber officinale and Citrus limon have similarly shown good physicochemical stability and antioxidant retention on storage

(Builders *et al*., 2020), while sensory studies of herbal teas from Solanum nigrum and Solanumtorvum berries and spices have linked fermentation and processing choices to phenolic and antioxidant outcomes (Asante *et al*., 2024). Response-surface optimisation of ginger tea has likewise shown that spice concentration must be balanced carefully, since excess levels intensify pungency and can depress hedonic scores even as functional compound content rises (Wei *et al*., 2026). Despite this substantial body of work on herbal teas, tisanes, candies and lozenges, comparatively little research has focused on a simple, versatile, shelf-stable spice-based powder that can be added directly to milk, tea or water for daily consumption, combining sensory evaluation, nutrient composition, cost assessment, antioxidant/polyphenol estimation and consumer-awareness assessment for a single multi-spice formulation. Clove, among culinary spices, has been reported to show one of the highest antioxidant capacities of 26 spices tested owing to its eugenol content (Cortés-Rojas *et al*., 2014), and microscopic/organoleptic authentication studies confirm that black pepper, ginger, turmeric, cinnamon and related spices retain distinct, standardisable diagnostic and functional profiles suitable for formulated products (Khan *et al*., 2024). Furthermore, Moringastenopetala leaf studies confirm that simple hot-water/boiling preparation methods can efficiently extract polyphenolic antioxidants such as rutin from plant material, supporting the feasibility of a hot-water-reconstituted spice powder as a delivery format (Habtemariam and Varghese, 2015).

A preliminary consumer survey undertaken as part of this study indicated that although individual-spice use (particularly black pepper) is nearly universal, structured awareness of "spice powder" as a distinct formulated product exists in only about half of respondents, and regular use of established Ayurvedic formulations such as Trikatu, Sitopaladi and TriphalaChurna remains low. This gap between strong traditional spice knowledge and limited uptake of standardised formulated products was the primary motivation for the present work, which aimed to formulate, standardise and evaluate a natural spice-based herbal powder using black pepper, dried ginger, long pepper and cinnamon as a constant base, fortified with Myrobalan and turmeric at two increasing levels, and to assess its nutrient composition, cost, sensory acceptability, antioxidant activity and polyphenol content, alongside consumer awareness of spice-based formulations.

MATERIALS AND METHODS

Procurement of Ingredients: Black pepper (Piper nigrum), dried ginger (Zingiber officinale), long pepper (Piper longum), cinnamon (Cinnamomum verum), Myrobalan (Terminalia chebula) and turmeric (Curcuma longa) were procured from a local Ayurvedic store in Hyderabad, Telangana.

Formulation and Standardisation: A basic (control) formulation was prepared using black pepper, dried ginger, long pepper and cinnamon as a constant base. Two variations were standardised by incorporating Myrobalan and turmeric at increasing levels while proportionally adjusting black pepper and dried ginger (Table 1). All spices were sun-dried, individually dry-roasted at low temperature until aromatic, cooled, ground to a fine powder, blended according to formulation, sieved and stored in airtight containers. For consumption, ½ teaspoon (1.5 g) of powder was simmered in 150 mL of tea, milk or water at 100°C for 10-12 min and served hot.

Table 1. Ingredient composition of Basic and Variation formulations (g)

Ingredient	Basic (g)	Variation I (g)	Variation II (g)
Black pepper	30	20	10
Dried ginger	10	15	20
Long pepper	5	5	5
Cinnamon	5	5	5
Myrobalan	-	3	5
Turmeric	-	3	5

Nutrient Value Calculation: Energy, carbohydrate, protein, fat, fibre and total polyphenol content of the Basic and Variation formulations were calculated using the Indian Food Composition Tables (Longvah *et al*., 2017) and the Nutritive Value of Indian Foods (Gopalan *et al*., 2012).

Cost Analysis: The cost of raw ingredients was recorded at procurement and used to compute per-batch production cost, inclusive of labour, for the Basic and Variation formulations.

Sensory Evaluation: Sensory evaluation was carried out in the Department of Food and Nutrition, VeeranariChakaliIlamma Women's University, Koti, Hyderabad. Twenty semi-trained panellists rated appearance, colour, taste, texture, aroma and overall acceptability on a 5-point hedonic scale (5 = excellent, 4 = very good, 3 = good, 2 = fair, 1 = poor), using a structured score card; water was provided between samples for palate cleansing. Panellists with cough, sluggish metabolism, bloating, low appetite, throat infection/excess mucus, asthma, a Kapha-type constitution, or an interest in weight management or immune support were included, while those with ulcers, gastritis or high acidity, pregnant or lactating women, and children and elderly participants were excluded.

Nutrient Analysis: Total polyphenolic content and antioxidant activity of the Basic and Variation I samples were estimated by standard AOAC (2012.04) methods as per the FSSAI manual, at an accredited food-testing laboratory (Smart Food Lab).

Consumer Awareness Survey: A structured questionnaire-based survey (n = 53) was conducted to assess awareness, perception and usage patterns regarding spices, spice-based herbal powder and established Ayurvedic spice formulations (Chyawanprash, TriphalaChurna, Trikatu Powder, SitopaladiChurna, Ashwagandha Powder and Giloy Powder) among a cross-section of occupations, age groups and working patterns.

Statistical Analysis: Sensory data were subjected to one-way ANOVA to test for significant differences among the mean scores of the Basic and Variation formulations, with the null hypothesis of no significant difference accepted when the calculated F-value was less than the tabulated F-value at the 5% level of significance.

RESULTS AND DISCUSSION

In the present study, a control spice-based herbal powder was prepared alongside two variations, Variation I and Variation II.

Product Development: Food product development refers to a methodical procedure of developing a basic product into a value-added, nutritionally enhanced product to meet the needs of consumers, nutrition and changes in market trends. The nutritionally enhanced value-added products developed in this study are the spice-based herbal powder fortified with Myrobalan and turmeric powder.

Nutritive Value Calculation: The nutrients calculated for the raw ingredients of the recipe were energy, carbohydrates, protein, fats, fibre and polyphenol content; detailed tables of nutritive value are included in the Annexure. The data revealed a slight increase in the calorific value of Variation I and II compared to the basic recipe, with Variation II having the highest energy. Carbohydrates, fats and polyphenol content increased in Variation I and II compared to the basic sample, whereas protein and fibre content decreased.

Table 2. Nutritive value of spice-based herbal powder (per serving)

Nutrient	Basic	Variation I	Variation II
Energy (kcal)	121.93	134.4	140.93
Carbohydrates (g)	23.77	27.11	29.31
Protein (g)	4.68	4.5	4.19
Fat (g)	1.58	1.81	1.97
Fibre (g)	15.57	14.12	12.26
Polyphenol content (mg)	285.9	990.14	1484.5

Cost Analysis: The expenditure for production of the basic spice-based herbal powder was determined to be Rs. 80/-, and for Variation I and Variation II, the cost was determined to be Rs. 89.2/- and Rs. 96.2/- respectively.

Table 3. Cost analysis of Basic and Variations of spice-based herbal powder (Rs.)

Cost component	Basic	Variation I	Variation II
Ingredients	70/-	79.2/-	86.2/-
Labour	10/-	10/-	10/-
Total	80/-	89.2/-	96.2/-

Sensory Evaluation of Spice-Based Herbal Powder (Basic and Variations): The developed spice-based herbal powder (basic) and its two variations (Variation I and Variation II) were evaluated for their sensory attributes, namely appearance, colour, taste, texture, aroma and overall acceptability, using a 5-point hedonic scale. The mean sensory scores obtained for each attribute are presented in Table 4.

The mean score for appearance of Variation I was found to be 4.75, higher than the basic (4.65) and Variation II (4.40). This indicates that appearance improved slightly at the first level of spice fortification, while a further increase in spice concentration in Variation II slightly reduced visual appeal, most likely due to the darker and more concentrated colour imparted by the higher proportion of turmeric and dried ginger powder. These findings are consistent with Ginitri and Agung (2025), who reported that with increasing levels of leaf and spice powder incorporation, appearance scores of a herbal drink formulation declined due to the darker colour imparted by the added ingredients. The mean colour scores of the basic and Variation I were equal at 4.60, while Variation II recorded a marginally lower score of 4.50, mainly attributable to the deeper colour imparted by the increased concentration of turmeric and cinnamon powder. These findings are consistent with Ishchenko and Złotek (2025), who reported that increasing the level of herbal and spice additives in functional confectionery and powder-based products progressively darkens the product, causing a mild but consistent decline in colour scores.

The mean taste score of the basic was 4.75, higher than Variation I (4.60) and Variation II (4.40), demonstrating that taste acceptability decreased gradually with increasing levels of spice fortification, likely due to the pungent and slightly sharp notes imparted by black pepper and long pepper at higher concentrations. These findings are consistent with Asante *et al*. (2024), who reported that taste acceptability scores of herbal tea and spice formulations decreased as spice concentration increased, due to the intensifying pungency of the added spices. The basic recorded the highest texture score (4.80), compared with Variation I (4.48) and Variation II (4.45). The marginal decline in texture scores observed in the fortified variations may be attributed to the slightly altered consistency introduced by the higher spice powder content, consistent with Builders *et al*. (2020), who reported that increasing the proportion of native herb powder in herbal tea blends altered the physicochemical consistency of the product, resulting in a mild decline in texture scores. The basic recorded the highest aroma score (4.90), followed by Variation I (4.65) and Variation II (4.50). The gradual decline in aroma scores with increasing spice levels can be attributed to the intensifying pungent aroma of black pepper, long pepper and dried ginger as their concentration increased, consistent with Wei *et al*. (2026), who reported that increasing spice concentration in ginger tea formulations intensified pungent aroma notes, reflected in a gradual decline in aroma acceptability scores. The basic recorded the highest overall acceptability score (4.85), followed by Variation I (4.60) and Variation II (4.55). The gradual decrease in overall acceptability with increasing levels of spice fortification was largely due to changes in taste, texture and aroma. However, all samples received scores above 4.0, indicating good consumer acceptability across all three formulations, consistent with Perera *et al*. (2025), who reported that overall acceptability scores of herbal tea formulations declined slightly with higher levels of functional additive incorporation, while still remaining within the acceptable range on the hedonic scale.

From the results of one-way ANOVA for the mean sensory scores of the basic recipe, Variation I and Variation II, the F-calculated value (2.24) was lower than the F-table value (3.16) at the 5% level of significance, and the corresponding p-value was greater than 0.05. The results indicated no significant difference among the three formulations; the null hypothesis was therefore accepted, indicating that differences in formulation did not significantly influence sensory evaluation scores. The average sensory scores obtained for the three formulations were 4.85, 4.60 and 4.55 for the basic recipe, Variation I and Variation II respectively. The basic recipe recorded the highest mean sensory score and Variation II exhibited the lowest, these differences were statistically non-significant; the three formulations therefore showed comparable sensory characteristics. Overall, the sensory evaluation results indicate that all formulations were well accepted by the panellists. Despite slight variations in the mean sensory scores, the absence of a statistically significant difference suggests that the developed formulations possessed similar levels of consumer acceptability and sensory quality.

Nutrient Analysis for Spice-Based Herbal Powder: The nutrient estimation of total polyphenolic content and antioxidant value of the basic and Variation I of the spice-based herbal powder was carried out using standard AOAC (2012.04) methods as per the FSSAI manual, at Smart Food Lab.

Total Polyphenolic Content: Data obtained from nutrient analysis showed that the spice-based herbal powder Variation I had 2980 mg/100 g of polyphenolic content, while the basic powder had 2150 mg/100 g. The polyphenolic content increased by 830 mg/100 g, indicating that fortification with higher levels of spices significantly enhanced the antioxidant-related bioactive compounds in the product. These findings are consistent with Al-Habsi *et al*. (2025), who reported that the therapeutic and antimicrobial properties of spice blends are closely tied to their combined polyphenol load, and that formulations incorporating a greater diversity and concentration of spices consistently showed higher measurable polyphenol content than less heavily spiced counterparts.

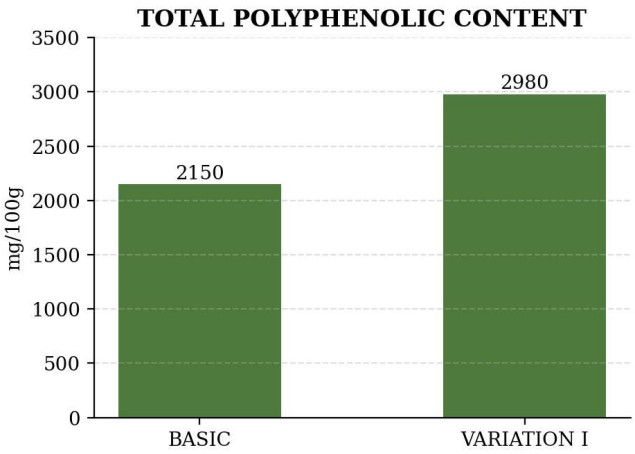

Figure 1. Total polyphenolic content of spice-based herbal powder (basic and Variation I).

Total Antioxidant Value: Obtained from nutrient analysis showed that the antioxidant value of Variation I was 87%, compared with 75% in the basic powder - an increment of 12 percentage points, further confirming that the increased spice concentration in Variation I contributed positively to the antioxidant potential of the formulated product. These findings are consistent with Spence (2025), who reported that blends combining pungent spices such as black pepper and long pepper with warming spices such as ginger and cinnamon consistently show higher measured antioxidant activity than any single spice used alone. This is also supported by Aariba and Raman (2025), who examined the therapeutic implications

of multi-herbal-powder-incorporated tea and reported that formulations combining several bioactive spices showed measurably higher antioxidant and functional potential than single-ingredient preparations.

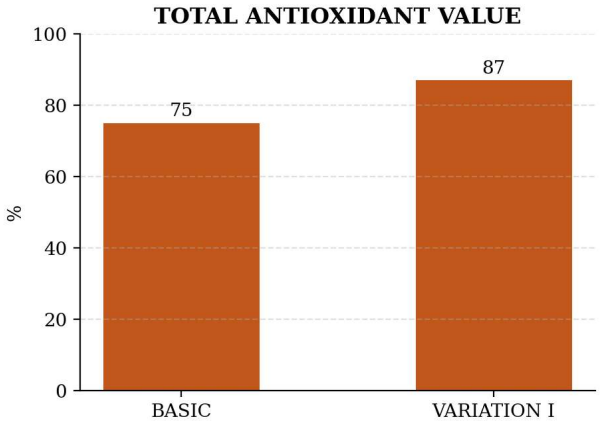

Figure 2. Total antioxidant value of spice-based herbal powder (basic and Variation I).

Comparison of Calculated and Analysed Polyphenol Content: The calculated polyphenol content of the basic sample was 285.9 mg/100 g, whereas the laboratory-analysed value was considerably higher at 2150 mg/100 g. Similarly, for Variation I, the calculated polyphenol content was 990.14 mg/100 g compared with an analysed value of 2980 mg/100 g. In both samples, the analysed polyphenol content was substantially higher than the calculated value. This difference may be attributed to the fact that calculated values are derived from standard reference food composition data for individual raw ingredients, which may underestimate the actual synergistic or concentrated polyphenol contribution of the combined spice blend, whereas laboratory analysis directly measures the polyphenolic compounds retained in the final processed product.

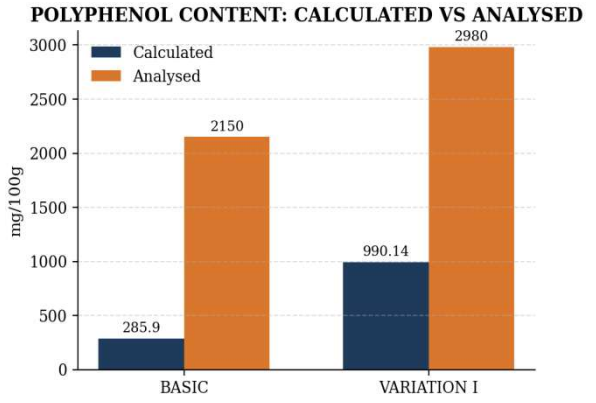

Figure 3. Comparison of calculated and analysed polyphenol content of spice-based herbal powder (basic and Variation I)

CONCLUSION

A natural spice-based herbal powder was successfully developed using black pepper, dried ginger, long pepper and cinnamon as a constant base, fortified with Myrobalan and turmeric at two increasing levels. Sensory evaluation showed that all three formulations were well accepted, with no statistically significant differences among them, while nutrient calculation and laboratory analysis confirmed that fortification with Myrobalan and turmeric progressively enhanced polyphenol content and antioxidant activity. The developed powder was therefore both sensorially acceptable and nutritionally beneficial, and represents a simple, shelf-stable format for incorporating functional spice bioactives into daily consumption.

RECOMMENDATIONS

- Clinical studies can be conducted to evaluate the health benefits (e.g., digestive, antioxidant, immune) of the herbal powder in human subjects.
- Storage/shelf-life studies can be conducted to determine the stability of the product over time.
- Nutrient analysis (antioxidant and polyphenol content) can also be extended to Variation II for a complete comparative picture.
- A larger-scale consumer awareness and acceptability study can be conducted to guide product positioning and marketing.
- Complete nutrient analysis (protein, fat, fibre via laboratory methods) of the products can be carried out to validate the calculated values.

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List of Abbreviations

ANOVA: Analysis of Variance; AOAC: Association of Official Analytical Collaboration (formerly Association of Official Analytical Chemists); FSSAI: Food Safety and Standards Authority of India; ICMR-NIN: Indian Council of Medical Research - National Institute of Nutrition; IFCT: Indian Food Composition Tables.

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