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Evaluation of the *In vitro* Antioxidant and Sensory Properties of Herbal Tea Premix Formulated with Green Tea (*Camellia sinensis*), Cinnamon (*Cinnamomum verum*), Ginger (*Zingiber officinale*), Basil (*Ocimum sanctum*), Ashwagandha (*Withania somnifera*), and Jaggery (*Saccharum officinarum*)

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This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

This study aimed to develop and evaluate an herbal tea premix formulated with green tea (*Camellia sinensis*), cinnamon (*Cinnamomum verum*), ginger (*Zingiber officinale*), basil (*Ocimum sanctum*), ashwagandha (*Withania somnifera*), and jaggery (*Saccharum officinarum*) for its therapeutic properties and sensory acceptability. Phytochemical analysis revealed that flavonoids (30% in S1) and phenols (25% in S1) were the dominant bioactive compounds, contributing to their strong antioxidant potential. The DPPH radical scavenging activity reached 75.4% at 50 µg/mL in S1, while FRAP (2.8 mmol Fe^{2+}/g) and TPC (82 mg GAE/g) confirmed its high antioxidant activity. The sensory evaluation identified Sample S1 as the most preferred formulation (overall acceptability 8.1) due to its balanced composition and enhanced flavor profile, whereas Sample S4 had the lowest taste acceptability (7.4). Microbial analysis confirmed safety, with no pathogens detected. This nutritionally stable premix holds promise as a functional beverage, but further clinical validation, bioavailability studies, and shelf-life assessment are required for commercialization.

Keywords: Herbal tea; therapeutic properties; bioactive compound; phytochemical screening; antioxidant assays; sensory evaluation.

1. INTRODUCTION

For many centuries people have appreciated herbal teas due to its multiple flavors and health advantages which depend mainly on the chosen herbs and spices (Huda et al*., 2024*). These teas serve as trendy beverages that people commonly as it provides refreshment and documented functional qualities that include antioxidant properties, anti-inflammatory responses, and adaptogenic effects (Amrute et al*., 2025*). A new herbal tea premix composed of green tea (*Camellia sinensis*), cinnamon (*Cinnamomum verum*), cloves (*Syzygium aromaticum*), tulsi (*Ocimum sanctum*), ginger powder (*Zingiber officinale*), and ashwagandha (*Withania somnifera*) and jaggery (*Saccharum officinarum*) was developed with both medicinal effects and pleasing taste characteristics. Green tea obtains its high antioxidant composition from polyphenols that mainly include catechins according to Yadav et al. (2017). The free radical-neutralizing compounds in these ingredients protect cardiovascular health while stopping chronic diseases (Gomes et al., 2024). Green tea functions as a gentle background flavor that unites the stronger tastes of cinnamon together with cloves and ginger (Mishra et al., 2021). The mixture includes cinnamon and cloves as these ingredients both fight inflammation and bacteria in the body. The bioactive compound cinnamaldehyde present in cinnamon displays effective antibacterial properties and reduces inflammation within the body (Yeh et al., 2013). The antibacterial characteristics of eugenol within cloves generate both hot and pungent sensations in tea beverages (Kaul & Joshi, 2001). These particular ingredients both boost the therapeutic values and complex flavor characteristics of this tea product.

Tulsi functions as an Ayurvedic medicine adaptogen that enables human bodies to balance stress levels and achieve equilibrium. The herb maintains immune health through various antioxidants that also decrease cortisol production and promote overall wellness (Bast et al., 2014). The functional properties together with soft aromatics in this mix originate from tulsi. The traditional medicine ingredient ginger is known to improve digestion because of its spicy and warming properties. The antioxidant and anti-inflammatory properties of gingerol act as its main active ingredient (Mao et al., 2019, Chong and Lim, 2012). Ashwagandha shows comprehensive scientific documentation about its effectiveness for stress reduction combined with better energy levels and improved holistic body balance. The incorporation of ashwagandha elevates the therapeutic characteristics of tea through functional beverage demand in the market (Mikulska et al., 2023). Jaggery maintains its mineral content such as iron, magnesium, potassium, and nutritional advantages as it derives from natural sugarcane production. Due to its molasses flavor the tea automatically

becomes sweeter which masks the bitter taste of herbs (Li et al., 2025). The market continues to choose herbal teas as functional beverages as consumers seek natural components in their beverages along with minimal processing. Research indicates that the market demand is growing for health-oriented products that combine scientific benefits with flavor and convenience options (Gomes et al., 2024). The research builds a tea premix solution that addresses market requirements by meeting sensory needs and functional specifications. The development of an advantageous herbal tea mixture requires experts to choose components wisely and determine accurate measurements while selecting proper preparation methods that maintain quality and functionality (Wang et al., 2023). The study follows a systematic approach to enhance the variables that influence consumer selection and the health advantages of premix tea. The blend contains antioxidant phytochemical ingredients which consist of green tea along with cinnamon and tulsi. A well-developed formulation process produces optimal outcomes for both product taste perception and product security and chemical stability (Lourenço et al., 2019, Deshmukh, 2024)). The antioxidant potential of the formulation increases as it contains green tea and cinnamon along with tulsi and jaggery which are locally sourced ingredients. This blend stands out due to its adaptive herb mix and natural sweetener components delivering health benefits with an enjoyable taste experience. The formulation enables a safe beverage that delivers both consumer satisfaction and meets the growing market demand for natural health beverages.

2. MATERIALS AND METHODS

The ingredients such as cinnamon (*Cinnamomum verum*), ginger (*Zingiber officinale*), basil leaf (*Ocimum tenuiflorum*), green tea (*Camellia sinensis*), ashwagandha (*Withania somnifera*) and jaggery (*Saccharum officinarum*) procured from local market of Pune were used to develop the herbal tea premix.

3. METHODOLOGY

3.1 Preparation

Raw materials ginger, cinnamon, basil leaf powder, green tea powder, ashwagandha, and jaggery powder were weighed in a weighing balance measured according to sample formulation. 100 ml distilled water was boiled in a boiling vessel up to 80 degrees Celsius. All raw ingredients were added to boiling water. The mixture was allowed to simmer gently for approximately 2 minutes, enabling the flavors to meld. The tea was then strained, and the heat was turned off. The measurements specified in Table 1 were utilized to create various tea formulations. Four distinct formulations (S1, S2, S3, and S4) of the herbal tea premix were developed using the ingredient ratios for 100 mL of water. The only difference between the formulations was the amount of ginger and cinnamon, with ginger ranging from 0.25 g in S1 to 1 g in S4 and cinnamon from 0.2 g in S1 to 0.5 g in S4. The variations were designed to improve the flavor and functional properties of the tea. The quantity of basil leaf remained consistent at 0.3 g across all samples, imparting its adaptogenic and therapeutic properties uniformly to each formulation. This systematic variation enables the evaluation of sensory attributes and functional benefits of different ingredient ratios (Shaik et al., 2023).

A digital balance measured each raw material exactly according to the sample formulation when preparing ginger, cinnamon, basil leaf powder, green tea powder, ashwagandha, and jaggery powder. All materials went into a boiling vessel containing hot distilled water at 80°C. The mixture needed a cooking period of 2-3 minutes to incorporate all flavors and bioactive compounds. After mixing the tea ingredients straining operations were performed followed by cooling down the mixture. The functional and sensory properties of formulations S1 to S4 were analyzed through modifications of ginger content from 0.25 g to 1 g alongside cinnamon amounts from 0.2 g to 0.5 g (Shaik et al., 2023; Mahato et al., 2019).

Table 1. Formulations for the Herbal tea premix

Formulations for 100 mL Water	Control (C)	S1	S2	S3	S4
Ginger	0 g	0.25 g	0.50 g	0.75 g	1 g
Cinnamon	0 g	0.2 g	0.3 g	0.4 g	0.5 g
Basil Leaf	0 g	0.3 g	0.3 g	0.3 g	0.3 g
Green Tea	0 g	0.25 g	0.5 g	0.75 g	1 g
Ashwagandha	0 g	0.1 g	0.2 g	0.3 g	0.4 g
Jaggery	0 g	6.5 g	6.8 g	6.5 g	6.8 g

3.2 Raw Material Analysis

The assessment of raw material quality evaluated their usefulness in creating the herbal tea premix. Drying the samples at 105°C in the oven reached a stable endpoint weight to stop microbial growth. To identify total mineral content Ash content determination was used through 550°C incineration (Nielsen & Ismail, 2017). Standard qualitative tests were utilized for phytochemical screening to identify bioactive compounds including alkaloids, flavonoids, tannins, phenols, and saponins. The analyses revealed how the nutritional properties and functional behavior of separate components worked along with confirming their readiness for formulation purposes. Phytochemical screening revealed the presence of bioactive compounds including alkaloids, flavonoids, tannins, phenols, and saponins.

3.3 Physicochemical Characteristics of Herbal Tea Premix

The physical and chemical characteristics of both starting substances and finished herbal tea premix were analyzed for quality assessment and nutrient evaluation. The oven drying method at 105°C enabled proper preservation to determine the moisture content of the samples (Raja et al., 2019, Tariq et al., 2016). The total mineral composition of the samples was determined by burning them at 550°C in a muffle furnace under incineration mentioned in Table 2. Fiber content measurement followed the AOAC method to explain its dietary advantages. Total nitrogen determination through the Kjeldahl method provides results for protein content. The difference method with moisture, protein, fiber, and ash variables was used to determine total carbohydrates for a balanced nutritional preparation (Xu et al., 2024; Li et al., 2025).

3.4 Sensory Evaluation of Prepared Herbal Tea Premix

A 9-point hedonic scale served to evaluate the sensory properties of the herbal tea premix including color, appearance, aroma, strength, and taste qualities as well as flavor intensity mouthfeel sensation, and overall acceptability rating. The evaluation of four formulations (S1-S4) occurred under identical preparation conditions. A standard process included heating 100 mL of water to 80°C for 2-3 minutes steep time of the samples before serving them at a controlled temperature for evaluation. The sensory aspects were scored according to their assessments through a rating scale which ranged from "extremely dislike" to "extremely like." The findings from sensory analysis helped choose the best product formulation that consumers would prefer.

3.5 Phytochemical Analysis

Centrifugation tests determined the composition of phytochemicals in the raw materials and prepared herbal tea premix. The tests for alkaloids utilized Dragendorff's reagent whereas aluminum chloride revealed flavonoids and tannins appeared through the ferric chloride test. Froth formation indicated the presence of saponins but the Folin-Ciocalteu reagent assay determined the phenolic compound concentration as mg Gallic acid equivalents (GAE)/g. The bioactive compounds found in the tea help it function as both an antioxidant and anti-inflammatory product and adaptogen which supports its therapeutic value as a functional drink (Dilshad et al., 2022).

3.6 Antioxidant Activity of Prepared Herbal Tea Mix

The antioxidant properties of herbal tea premix were determined through DPPH, Ferric Reducing Antioxidant Power (FRAP), and Total Phenolic Content (TPC) testing protocols. The DPPH (8691 and 3680 (µg/mL)) assay determined the free radical scavenging potential through IC50 measurement expressed in µg/mL (Baliyan et al., 2022). The FRAP assay evaluated electron-donating capability and returned results in mmol Fe^{2+} equivalents per gram. The TPC assay measured phenolic compounds as mg GAE/g to validate the antioxidant properties of the tea mix (Parikh & Patel, 2018). The established oxidative stress reduction capacity of tea through these findings supports its function as a beneficial beverage for health promotion.

4. RESULTS

4.1 Raw Material Analysis

The examination of the herbal tea premix showed moisture content between 5.8% and 8.3% ash content at 6.8% and fiber content ranging from 0.5% to 12.3%. These results ensured both stability and nutritional advantages. The herbal tea premix gets its sweet flavor from

jaggery-based carbohydrates which make up 50.6% of its composition mentioned in Table 2. Product analysis results validate the functional value and health benefits present in the ingredients.

4.2 Sensory Evaluation of Prepared Herbal Tea Premix

The acceptability evaluation included a 9-point hedonic scale to measure color, aroma, flavor, taste, mouthfeel, and overall reaction to the samples. The formulation of Sample S1 achieved an 8.1 overall acceptability rating as participants found its flavor and aroma profile (8.6) to be perfectly balanced thus making it the preferred choice. The high ginger and cinnamon contents in Sample S4 resulted in poor taste (7.2) and acceptability (7.4) scores as the flavor became intense and unbalanced mentioned in Table 3.

4.3 Chemical Composition of Herbal Tea Samples (S1–S4)

The protein along with ash content and moisture measurements of different formulations enabled an assessment of the nutritional quality of herbal tea premix. The protein levels in the solutions rose proportionally to the ingredient amounts in the samples starting at 0.2 g in S1 up to 1.27 g in S4. The S1 formulation contained 4.05 grams of ash but S4 contained 4.67 grams of ash. All four formulations-maintained moisture content at levels that preserve stability mentioned in Table 4.

Table 2. Proximate Composition of Raw Materials and Herbal Tea Premix

Component	Green Tea	Cinnamon	Tulsi	Ginger	Ashwagandha	Jaggery	Herbal Tea Premix
Moisture (%)	6.2	7.0	5.8	8.3	7.5	5.2	6.1
Fat (%)	1.2	2.1	0.8	1.9	2.5	0.1	1.4
Protein (%)	18.3	4.2	3.9	2.7	4.5	0.6	5.1
Carbohydrates (%)	40.8	35.4	48.2	42.1	38.7	93.2	50.6
Ash (%)	5.9	6.3	4.1	5.5	6.8	1.2	5.2
Fiber (%)	11.5	12.3	9.6	10.8	8.7	0.5	10.1
SE	0.08	0.09	0.05	0.09	0.05	0.03	0.05
CD at 5%	0.23	0.26	0.21	0.27	0.21	0.23	0.22

Table 3. Sensory Evaluation Scores for Herbal Tea Premix Samples

Sample	Color & Appearance	Aroma	Flavor	Taste	Mouthfeel	Overall Acceptability
S1	8.3	8.6	8.3	7.7	7.9	8.1
S2	8.1	8.2	7.8	7.6	7.8	7.8
S3	8.0	7.8	7.8	7.6	7.7	7.7
S4	7.7	7.7	7.7	7.2	7.2	7.4
SE	0.079	0.122	0.076	0.076	0.103	0.097
CD at 5%	0.179	0.276	0.172	0.172	0.233	0.220

Table 4. Chemical composition of Herbal Tea Samples (S1–S4)

Sample	Protein (g)	Ash (g)	Moisture (%)
S1	0.2	4.05	NA
S2	0.62	4.32	1.08
S3	1.1	4.0	1.0
S4	1.27	4.67	1.34
SE	**0.20**	**0.14**	**0.11**
CD at 5%	**0.61**	**0.50**	**0.32**

The protein content increased from 0.2 g in S1 to 1.27 g in S4 while ash content rose from 4.05 g in S1 to 4.67 g in S4 and moisture content rose from 36.04 g in S1 to 47.24 g in S4 as the ingredient concentrations increased as shown in Table 4. The ash content in the samples ranging from 4.05 g in S1 to 4.67 g in S4 maintained acceptable mineral content and stability. This is similar to a previous study by Raja et al. (2019).

4.4 Phytochemical Analysis of Prepared Herbal Tea Premix

The plant compounds in raw materials and finished herbal tea premix products. Sample S1 demonstrated the strongest concentrations of flavonoids at 30% and phenols at 25% as these components drive therapeutic and antioxidant effects. Sample S1, which had the highest sensory acceptability, demonstrated the strongest concentrations of flavonoids (30%) and phenols (25%), indicating their superior antioxidant properties. The adaptogenic properties of saponins reached their peak value (20%) in Sample S3 while Sample S4 demonstrated higher levels of tannins (15%) known for their antimicrobial effects mentioned in Table 5. The level of alkaloids that aid stress relief showed no variations between all four samples (10%).

4.5 Distribution of key Bioactive Compounds

The analysis of the herbal tea premix for the relative abundance of key bioactive compounds is illustrated in Fig. 2. Flavonoids and phenols make up the majority (30%) and (25%) respectively, which is the major contribution to the antioxidant and therapeutic properties of the tea. Adaptogenic and immune-boosting saponins (20%) follow. Alkaloids (10%) along with tannins (15%) account for a lesser portion of antimicrobial and anti-inflammatory effects in the tea premix. The phytochemical distribution in the tea premix created a balanced profile that produced enhanced functional and medicinal properties.

Table 5. Phytochemical Composition of Herbal Tea Premix (% per Sample)

Compound	S1	S2	S3	S4
Flavonoids	30	28	27	26
Phenols	25	23	22	21
Saponins	20	19	20	18
Tannins	15	14	13	15
Alkaloids	10	10	10	10
SE	0.20	0.46	0.13	0.09
CD at 5%	0.60	1.25	0.40	0.28

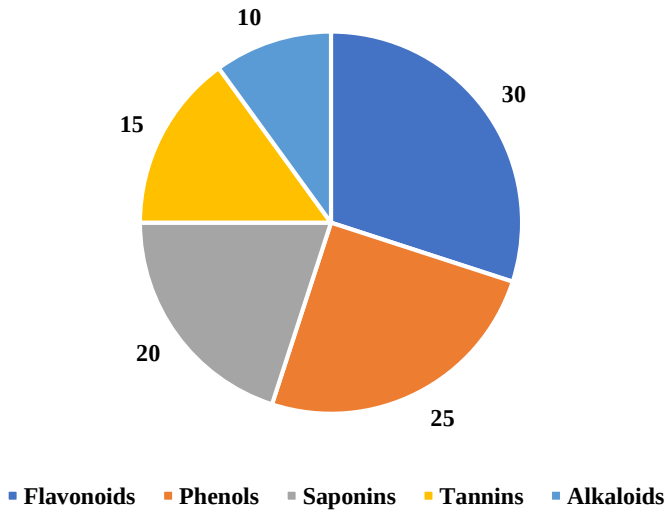

Fig. 1. Distribution of Key Bioactive Compounds in Herbal Tea Premix (%)

4.6 Antioxidant Activity of Prepared Herbal Tea Mix

Assessments were conducted on raw materials' phytochemical composition and the prepared herbal tea premix. The flavonoid content in Sample S1 measured at 30% along with 25% phenols resulted in the highest levels of antioxidant properties and therapy benefits. A high percentage of adaptogenic saponins (20%) was detected in Sample S3 followed by antimicrobial tannins (15%) in Sample S4. The alkaloid concentrations in all samples showed no variation at 10% mentioned in Table 6.

The radical scavenging activity (%) of herbal tea premix and ascorbic acid is illustrated in Fig. 2 at different concentrations between 10-50 µg/mL. Results demonstrated that the antioxidant capacity of herbal tea premix achieved 75.4% at 50 µg/mL although ascorbic acid displayed superior activity with 91.6%.

4.7 Microbial Safety Analysis

The microbial testing showed that the tea contained no harmful pathogens among Salmonella, *E. coli*, and *Staphylococcus aureus*. The conducted microbial analysis indicated the complete absence of yeast and mold (<10 CFU/g) and the total plate count was below 10^2 CFU/g thus assuring safety for tea consumption mentioned in Table 7.

Table 6. Antioxidant Activity of Herbal Tea Premix Samples

Sample	DPPH IC50 (µg/mL)	FRAP (mmol Fe^{2+}/g)	TPC (mg GAE/g)
S1	30.4	2.8	82
S2	32.1	2.6	78
S3	35.4	2.4	74
S4	38.2	2.1	70
SE	0.19	0.08	0.70
CD at 5%	0.60	0.24	2.18

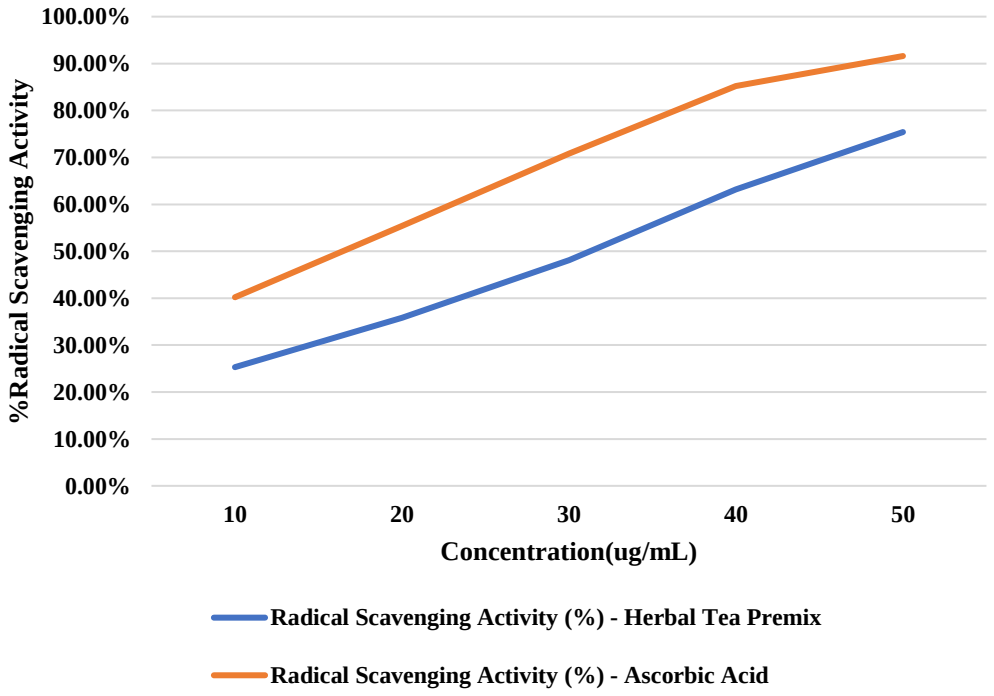

Fig. 2. Comparison of Antioxidant Activity of Herbal Tea Premix and Ascorbic Acid (DPPH Assay)

Table 7. Microbial Safety Analysis of Herbal Tea Premix

Microorganism Tested	Results
Total Plate Count	$<10^2$ CFU/g
Yeast & Mold Count	<10 CFU/g
Salmonella spp.	Not Detected
E. coli	Not Detected
Staphylococcus aureus	Not Detected

**Each value is a mean of three determination*

5. DISCUSSION

The study examined the herbal tea premix through phytochemical analyses and antioxidant evaluations, in addition to conducting sensory assessments and microbial safety tests. Analysis through Table 5 and Fig. 2 revealed essential bioactive compounds including flavonoids reached 30% in S1, S2 at 28%, S3 at 27%, and S4 at 26% while phenols measured at 25% in S1, 23% in S2, 22% in S3, and 21% in S4. The identified compounds function as antioxidants while simultaneously working as anti-inflammatory substances adaptogens and immune system strengtheners. Sample S1 demonstrated the greatest antioxidant potential because it contained the highest amounts of flavonoids and phenolic compounds thus proving effective radical scavenging ability (Dilshad et al., 2022).

The tea premix antioxidant capacity illustrated in Fig. 3 indicates that radical scavenging activity increased dependent on concentration from zero to 75.4% at 50 µg/mL for Sample S1. The antioxidant capacity of Sample S2 achieved 72.1% while Sample S3 reached 69.4% and Sample S4 obtained 65.8% when measured at 50 µg/mL. The combination of FRAP value (2.8 mmol Fe^{2+}/g in S1) with TPC value (82 mg GAE/g in S1) demonstrates that herbal tea has strong functional potential to fight oxidative stress mentioned in Table 6 (Baliyan et al., 2022; Yeh et al., 2013).

The sensory panel determined Sample S1 as the most acceptable due to its balanced mixture and pleasant aromas (8.6) and flavors (8.3) which earned it a total rating of 8.1 in Table 4. The combination of high ginger and cinnamon content in Sample S4 caused consumers to rate it with the lowest acceptability (7.4) and taste score (7.2) since the balance between ingredients matters (Shaik, 2023).

Table 7 shows the results of microbial testing which verifies that Salmonella, *E. coli*, and *Staphylococcus aureus* do not exist in the herbal tea premix product while ensuring its compliance with food safety regulations (Nielsen & Ismail, 2017).

The study indicates that premixed herbal tea serves as an accepted beneficial drink as it contains robust antioxidant characteristics and nutritious benefits. The field needs more research which should confirm bioactive elements through clinical trials along with determining their shelf-life times and bioavailability to enhance market readiness.

6. CONCLUSION

The study demonstrates that the herbal tea premix possesses functional beverage qualities as it contains multiple essential therapeutic and nutritional attributes. The premix contains organic and inorganic components which are verified through ash content analysis for essential minerals such as calcium, magnesium, and potassium while protein content shows the presence of amino acids. The optimal moisture levels in the tea mix maintained stability for both tea production and storage processes. Phytochemical analysis detected five compounds including flavonoids, phenols, saponins, tannins, and alkaloids which exhibited antioxidant, antimicrobial, and adaptogenic effects. The sensory evaluation found Sample S1 to be the most preferred formulation due to its balanced ingredients and high acceptability rating of 8.1. The microbial safety checks showed no presence of dangerous pathogens. The findings lay down a solid basis that will aid product creation as well as regulatory compliance and quality control procedures. Future investigations need to perform clinical verifications examine bioavailability and conduct shelf-life tests because these steps will verify the product's health advantages and improve commercial viability for health-oriented functional beverage applications.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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