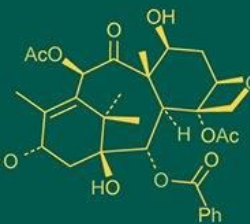
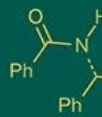
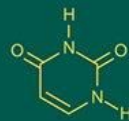
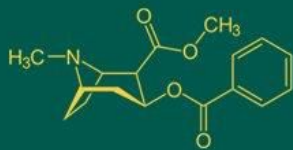


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(1): 1449-1455
www.biochemjournal.com
Received: 13-11-2025
Accepted: 17-12-2025

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Effect of edible flower fortification on sensory quality and phytochemical composition of green tea (*Camellia sinensis*) infusions

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i1r.7304>

Abstract

Green tea (*Camellia sinensis*) is a globally consumed beverage recognized for its rich phytochemical profile and associated health benefits. Herbal and floral infusions have gained increasing attention as functional beverages due to their ability to deliver bioactive plant compounds that may mitigate oxidative stress and metabolic disorders. The present study aimed to compare the sensory attributes and phytochemical composition of conventional green tea and a value-added floral green tea formulated with green tea (60%), hibiscus (*Hibiscus rosa-sinensis*, 20%), and marigold (*Tagetes erecta*, 20%) petals in a 3:1:1 ratio, prepared using both hot and cold infusion methods. Control green tea (GT) and floral green tea (FGT) infusions were evaluated for sensory characteristics and biochemical constituents, including reducing sugars, protein, total phenolics, tannins, flavonoids, and caffeoylquinic acid. Sensory evaluation revealed that value-added FGT, prepared by both hot and cold infusion methods, received significantly higher scores for appearance, color, aroma, taste, flavor, and overall acceptability compared to GT. Phytochemical analysis showed that hot-infused FGT exhibited increased reducing sugar (0.243 mg g⁻¹) and protein content (28.27 mg g⁻¹) relative to hot GT. However, a reduction in polyphenol-related compounds was observed in FGT, with decreases in total phenolic content (from 251.67 to 161.34 mg GAE g⁻¹), total tannins (from 33.05 to 22.87 mg TAE g⁻¹), total flavonoids (from 1.44 to 0.75 mg QE g⁻¹), and caffeoylquinic acid (from 1.907 to 1.08 mg CGAE g⁻¹). Similar trends were observed in cold-infused samples, except for reducing sugars and protein that remained higher in floral formulations. Hence, the incorporation of edible hibiscus and marigold petals enhances the sensory quality and nutritional attributes of green tea while retaining substantial bioactive potential. Value-added floral green tea may therefore represent a promising functional beverage with improved consumer acceptability and potential health benefits.

Keywords: Green tea, value-addition, hibiscus, marigold, phytochemicals, sensory evaluation

1. Introduction

Tea (*Camellia sinensis*) is one of the most widely consumed beverages worldwide and is highly valued for its pleasant sensory attributes and abundance of bioactive compounds. Green tea, in particular, is rich in catechins, phenolic acids, flavonoids, amino acids and vitamins that collectively contribute to its well-documented antioxidant, anti-inflammatory, antimicrobial, and cardiometabolic health benefits. Owing to these properties, green tea has attracted sustained scientific interest and remains a cornerstone of functional beverage research. In recent years, the beverage industry has increasingly focused on the concept of value addition, wherein conventional products are enhanced through the incorporation of natural ingredients to improve nutritional quality, sensory appeal, and market value. The value addition in food science involves transforming simple products into more functional and consumer-acceptable forms by integrating bioactive-rich components Purohit *et al.*, (2021) [20]. Within this context, the fortification of tea with botanicals has emerged as a promising strategy to meet evolving consumer preferences for health-oriented and sensorially pleasing beverages.

Among botanical ingredients, edible flowers have gained attention due to their vibrant colors, distinctive aromas and rich phytochemical composition. Edible flowers contribute anthocyanins, carotenoids, flavonoids, phenolic acids and sugars that not only enhance visual

and olfactory properties but also provide additional nutritional and functional benefits. Their incorporation into beverages aligns with the growing global trend toward herbal and floral infusions that are increasingly perceived as natural and wellness-oriented drink options. Although specific combinations of tea with edible flowers remain underexplored, broader research on herbal-infused beverages supports this approach. Chandrasekara and Shahidi (2018) [2] highlighted the increasing consumer demand for natural beverages enriched with antioxidants and bioactive compounds, driven by growing awareness of diet-related health benefits. Consumers are now actively seeking beverages that offer relaxation, aroma, and functional health advantages, making herbal fortification a key innovation area in beverage formulation.

Historically, the addition of medicinal plants to tea has been a common practice across cultures. Green tea extracts combined with natural ingredients such as mint, cloves, and ginger exhibited enhanced health-promoting effects, particularly in reducing oral pathogenic activity Somasundaram *et al.*, (2019) [23]. Similarly, traditional processing methods such as steaming oolong tea with extracts of gooseberry, turkey berry and wild betel leaf have been documented to impart antidiabetic potential and demonstrate the long-standing role of plant-based fortification in enhancing the functional properties of tea. Edible flowers such as hibiscus (*Hibiscus rosa-sinensis*) and marigold (*Tagetes erecta*) possess distinct phytochemical profiles that can complement the bioactive composition of green tea. Hibiscus flowers are rich in anthocyanins and organic acids contributing to strong antioxidant activity and characteristic red coloration, while marigold petals contain carotenoids and flavonoids known for antioxidant and anti-inflammatory properties (Kumari *et al.*, 2021; Thapa, *et al.*, 2025) [13, 25]. Recent reviews have emphasized the potential of edible flowers as functional food ingredients capable of enhancing both sensory quality and nutritional value when incorporated into beverages.

The combination of green tea with hibiscus and marigold infusions presents a promising functional beverage due to the complementary biological activities of their phytochemicals. Catechins present in green tea exhibit antioxidative, antiviral, antibacterial, and anti-inflammatory effects, contributing to immune modulation and protection against infections (Ide *et al.*, 2015) [10]. Additionally, the presence of theanine and vitamin C in green tea has been associated with immune-boosting and stress-relieving effects. Despite the worldwide popularity of herbal and floral beverages, systematic studies evaluating the sensory attributes and biochemical composition of green tea fortified with edible flowers such as hibiscus and marigold are scarce. Recent literature highlights the need for experimental evaluation of novel beverage formulations to understand interactions among phytochemicals, extraction efficiency, and sensory acceptance (Preciado-Saldana *et al.*, 2019) [19]. Moreover, infusion conditions such as temperature and duration are known to significantly influence the extraction of bioactive compounds from tea leaves and plant materials. In view of these considerations, the present study was undertaken to evaluate the sensory attributes and biochemical composition of value-added floral green tea infusions prepared using hibiscus and marigold petals under hot and cold infusion methods. The findings aim to contribute scientific insight into edible

flower-based tea fortification and support the development of novel functional beverages with improved consumer appeal and potential health benefits.

2. Materials and Methods

2.1 Source of samples

Green tea leaves (*Camellia sinensis*) were procured from a tea estate located in Chikamagaluru, Karnataka, India. Edible hibiscus flowers (*Hibiscus rosa-sinensis*) were collected from plants grown in the local Hubli-Dharwad region, while marigold flowers (*Tagetes erecta*) were collected locally from the same area. The flower petals were separated manually, washed thoroughly with distilled water and dried in a hot air oven at 35 °C until a constant weight was obtained.

Dried green tea leaves and edible flower petals were ground separately into a fine powder and passed through a 20-mesh sieve to ensure uniform particle size. Value-added green tea was prepared by blending green tea powder with hibiscus and marigold petal powders in a ratio of 3:1:1. Accordingly, one gram of the floral green tea blend consisted of 0.6 g green tea powder, 0.2 g hibiscus petal powder and 0.2 g marigold petal powder. Green tea powder without the addition of edible flowers served as the control sample.

2.2 Preparation of value-added green tea infusions

2.2.1 Hot infusion

Hot infusions were prepared by infusing one gram of fine tea powder (control and value-added samples) in 100 mL of distilled water maintained at 95 °C for 5 min. After infusion, the extracts were allowed to cool to room temperature and filtered through Whatman No. 1 filter paper (Komes *et al.*, 2010) [12].

2.2.2 Cold infusion

Cold infusions were prepared by extracting one gram of fine tea powder (control and value-added samples) in 100 mL of distilled water at room temperature with continuous swirling for 2 h. The extracts were subsequently filtered through Whatman No. 1 filter paper.

All samples were analysed for biochemical components within 24 h of extraction and freshly prepared samples were assessed for sensory evaluation. Each experiment was conducted in triplicate.

2.3 Chemicals

All analytical grade chemicals used in the study were procured from SDS Fine Chemicals, Hubli, Karnataka, India. The reagents included 3,5-dinitrosalicylic acid (DNS) reagent, glucose solution, Rochelle salt solution (potassium sodium tartrate), Coomassie Brilliant Blue G-250, ethanol, orthophosphoric acid, bovine serum albumin (BSA), Folin-Ciocalteu reagent, sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH), gallic acid, tannic acid solution, aluminium chloride solution (AlCl_3), quercetin, sodium molybdate, dipotassium hydrogen phosphate, potassium dihydrogen phosphate, and chlorogenic acid solution. All chemicals were of analytical grade.

2.4 Sensory analysis

Sensory evaluation of control and value-added green tea infusions was carried out by a trained panel consisting of fifteen healthy, non-smoking individuals aged between 23 and 50 years from the Department of Food Science and

Nutrition, University of Agricultural Sciences (UAS), Dharwad. Freshly prepared tea infusions were served to the panellists in transparent glass cups, each coded with random three-digit numbers to eliminate bias.

Panellists evaluated the samples for appearance, color, aroma, taste, flavour and overall acceptability using a 9-point hedonic scale, where 1 represented "dislike extremely," 5 represented "neither like nor dislike," and 9 represented "like extremely," following the method described by Lee *et al.*, (2010) [14]. Drinking water was provided between sample evaluations to cleanse the palate and minimize carry-over effects.

2.5 Determination of reducing sugar content

Reducing sugar content of the tea infusions was estimated using the 3,5-dinitrosalicylic acid (DNS) method as described by Sadasivam and Manickam (2015) [21]. Standard glucose solutions ranging from 100 to 1000 μg were prepared and aliquoted into a series of labelled test tubes, with the final volume adjusted to 1 mL using distilled water. A blank containing 1 mL of distilled water was prepared simultaneously. For sample analysis, freshly prepared tea infusions were appropriately diluted (200 μL infusion + 800 μL distilled water) to obtain a final volume of 1 mL. DNS reagent (0.5 mL) was added to each tube, mixed thoroughly. The reaction mixtures were heated in a boiling water bath for 5 min. The tubes were then cooled to room temperature and the volume was adjusted to 10 mL using distilled water. Absorbance of the standards and samples was measured at 540 nm against the reagent blank using a UV-Visible spectrophotometer. Reducing sugar content was calculated from the standard calibration curve and expressed as mg Glucose g^{-1} of sample.

2.6 Determination of protein content

Protein content of the tea infusions was determined using the Bradford dye-binding method following the procedure described by (Bradford, 1976) [1]. Bovine serum albumin (BSA) standard solutions (0-1.0 mL) were prepared and the volume was adjusted to 1 mL with distilled water. Bradford reagent (5 mL) was added to each tube, mixed well and incubated at room temperature for 5 min. 50 μL of tea infusion was diluted to 1 mL with distilled water, followed by the addition of Bradford reagent. Absorbance was measured at 595 nm using a spectrophotometer. Protein concentration was calculated using the BSA standard curve and expressed as mg BSA g^{-1} of sample.

2.7 Determination of total phenolic content (TPC)

Total phenolic content of the tea infusions was determined using the Folin-Ciocalteu method (Singleton *et al.*, 1999) [22]. An aliquot of diluted tea infusion (10 μL infusion + 990 μL distilled water) was mixed with 0.5 mL of Folin-Ciocalteu reagent (1:1 diluted) and 4.8 mL of distilled water. The mixture was vortexed and incubated at room temperature for 30 min. Subsequently, 1.5 mL of 20% sodium carbonate solution and 3.2 mL of distilled water were added. The reaction mixture was allowed to stand for 2 h. Gallic acid standards (10-50 μg) were treated similarly. Absorbance was measured at 760 nm and TPC was expressed as mg gallic acid equivalents per gram (mg GAE g^{-1}).

2.8 Determination of total tannin content

Total tannin content was estimated using the Folin-Ciocalteu method as described by Singleton *et al.*, 1999 [22].

An aliquot of 0.01 mL of tea infusion was added to a 10 mL volumetric flask containing 7.5 mL distilled water, followed by 0.5 mL Folin-Ciocalteu reagent and 1 mL of 35% sodium carbonate solution. The volume was made up to 10 mL with distilled water, mixed thoroughly, and incubated at room temperature for 30 min. Tannic acid (20-100 μg mL^{-1}) was used as reference standard. Absorbance was measured at 760 nm using a visible spectrophotometer. Total Tannin content was expressed as mg tannic acid equivalents per gram (mg TAE g^{-1}).

2.9 Determination of total flavonoid content

Total flavonoid content was determined using the aluminium chloride method (Chang *et al.*, 2002) [3]. Quercetin (20-100 μg mL^{-1}) was used as standard. The reaction mixture contained 5.6 mL with distilled water and 0.3 mL of 10% aluminium chloride solution. After 5 min, 2.0 mL of 1 M sodium hydroxide was added and the final volume was adjusted to 10 mL with distilled water. Control and Value-added tea infusion samples (100 μL infusion + 900 μL distilled water) were treated similarly. Absorbance was recorded at 510 nm using a UV-Visible spectrophotometer. Total Flavonoid content was expressed as mg quercetin equivalents per gram (mg QE g^{-1}).

2.10 Determination of caffeoylquinic acid content

Caffeoylquinic acid content (CQAC) was quantified using the molybdate assay as described by Tan *et al.*, (2014) [24]. Tea infusion (0.3 mL) was mixed with 2.7 mL of molybdate reagent, shaken thoroughly and incubated at room temperature for 10 min. Absorbance was measured at 370 nm against blank. CQAC was calculated using a chlorogenic acid standard curve and expressed as mg chlorogenic acid equivalents per gram (mg CGAE g^{-1}).

2.11 Statistical analysis

All experiments were conducted in triplicate and the results are expressed as mean values $\pm$ standard deviation. Statistical analysis was performed using SPSS software (version 23.0.0.0). A one-way analysis of variance (ANOVA) was applied to evaluate differences among samples. Statistical significance was determined at $p < 0.01$ following the procedure described by Gomez and Gomez (1984). Mean values followed by the same superscript letter within a row were considered not significantly different, whereas different superscripts indicated significant differences at $p < 0.01$.

3. Results and Discussion

3.1 Sensory evaluation

The sensory evaluation data clearly demonstrated that the value-added floral green tea (GT + Hibiscus 20% + Marigold 20%) was significantly more acceptable than the control green tea across all sensory attributes and infusion methods (Table 1). In hot infusions, floral green tea exhibited markedly higher scores for appearance (8.00), color (8.13), aroma (8.50), taste (8.50), flavor (8.00), and overall acceptability (8.90) compared to control green tea that ranged from 6.53 to 7.03. A similar trend was observed for cold infusions, where floral green tea consistently outperformed the control, although with comparatively lower absolute scores. The statistical differences indicated by different superscripts confirm significance at $p < 0.01$. The enhanced appearance and color of floral green tea could be attributed to the presence of anthocyanins from hibiscus and

carotenoids from marigold petals that had intensified visual appeal and were known to positively influence consumer preference. Aroma and flavor improvements were likely associated with the release of floral volatiles and organic acids from hibiscus that impart fruity and mildly acidic notes that complement the vegetal flavor of green tea (Preciado-Saldana *et al.*, 2019) [19]. Similar sensory enhancement has been reported in hibiscus-based and blended tea beverages, where floral components improved aroma complexity and overall palatability (Nguyen and Chuyen, (2020) [18].

Hot infusions consistently received higher sensory scores than cold infusions for both control and floral teas. This observation was in agreement with previous studies demonstrating that higher extraction temperatures enhance the release of aroma compounds, pigments and taste-active

components, thereby intensifying sensory perception (Komes *et al.*, 2010; Chandrasekara & Shahidi, 2018) [12, 2]. In contrast, cold infusion limits the extraction of volatile and color-forming compounds that resulted in comparatively lower sensory scores.

Furthermore, the improved taste and flavor scores of floral green tea may be linked to partial masking of bitterness and astringency typically associated with green tea catechins. Floral components had been shown to reduce perceived astringency and bitterness by balancing polyphenol-driven sensory attributes, thereby enhancing consumer acceptance (Yang and Lee, 2020) [28]. Overall, the results indicated that incorporation of hibiscus and marigold petals significantly enhances the sensory quality of green tea, particularly when prepared by hot infusion, supporting the potential of edible-flower fortification in functional beverage development.

Table 1: Sensory evaluation of Green Tea and Floral Value-added Green Tea of both Hot and cold infusions.

Sensory Characteristics	HOT Infusion		Cold Infusion	
	Green Tea (Control)	Floral value-added Green Tea (3:1:1)	Green Tea (Control)	Floral value-added Green Tea (3:1:1)
Appearance	6.75±0.19 ^b	8.00±0.03 ^a	5.75±0.1 ^b	7.00±0.45 ^a
Color	6.75±0.16 ^b	8.13±0.35 ^a	5.75±0.39	6.13±0.35 ^a
Aroma	7.00±0.07 ^b	8.50±0.26 ^a	5.25±0.21 ^b	6.50±0.26 ^a
Taste	6.53±0.55 ^b	8.50±0.36 ^a	5.63±0.19 ^b	6.50±0.16 ^a
Flavor	6.63±0.32 ^b	8.00±0.53 ^a	5.88±0.29 ^b	7.00±0.33 ^a
Overall acceptability	7.03±0.12 ^b	8.90±0.26 ^a	5.63±0.32 ^b	7.00±0.26 ^a

3.2 Phytochemical composition of control and floral green tea infusions

The phytochemical composition of control green tea (GT) and value-added floral green tea (FGT) prepared using hot and cold infusion methods revealed significant differences ($p < 0.01$) across all measured parameters, including reducing sugar content (RSC), protein content, total phenolic content

(TPC), total tannin content (TTC), total flavonoid content (TFC), and total caffeoylquinic acid content (TCAC) were tabulated in Table 2. These variations highlight the combined influence of infusion temperature and edible flower fortification on the chemical profile of green tea infusions.

Table 2: Biochemical composition of Green Tea and Floral Value-added Green Tea of both Hot and cold infusions.

Biochemical Profile	HOT Infusion		Cold Infusion	
	Green Tea (Control)	Floral value-added Green Tea (3:1:1)	Green Tea (Control)	Floral value-added Green Tea (3:1:1)
Reducing Sugar Content (mg/g)	0.049±0.003 ^b	0.243±0.001 ^a	0.036±0.002 ^b	0.192±0.003 ^a
Protein Content (mg/g)	15.55±0.12 ^b	28.27±0.40 ^a	30.8±0.15 ^b	38.33±0.54 ^a
Total Phenol Content (mg GAE/g)	251.67±0.40 ^a	161.34±0.16 ^b	194.67±0.50 ^a	105.74±0.34 ^b
Total Tannin Content (mg TAE/g)	33.05±0.09 ^a	22.87±0.19 ^b	29.90±0.63 ^a	21.62±0.46 ^b
Total Flavonoid Content (mg QE/g)	1.44±0.02 ^a	0.75±0.02 ^b	0.95±0.03 ^a	0.61±0.04 ^b
Total caffeoylquinic acid Content (mg CGAE/g)	1.907±0.032 ^a	1.08±0.024 ^b	1.476±0.014 ^a	0.775±0.024 ^b

3.2.1 Reducing sugar content (RSC)

Reducing sugar content was significantly higher in floral green tea infusions compared to control green tea under both hot and cold extraction conditions. Among all samples, hot floral green tea exhibited the highest RSC (0.243 mg g⁻¹), which was nearly five-fold greater than that of hot control green tea (0.049 mg g⁻¹). A similar pattern was observed in cold infusions, where floral green tea recorded an RSC of 0.192 mg g⁻¹ compared to 0.036 mg g⁻¹ in the control. The observed increase in reducing sugars can be attributed primarily to the contribution of soluble carbohydrates from hibiscus and marigold petals. Previous studies had reported appreciable amounts of free sugars and soluble polysaccharides in hibiscus and marigold flowers that readily diffuse into aqueous media during infusion (Vaithiyanathan & Sundaramoorthy, 2016; Wang *et al.*, 2021) [27, 29]. The enhanced extraction of these sugars during hot infusion further explains the significantly higher RSC

values, as elevated temperatures promote cell wall disruption and solubilization of low-molecular-weight carbohydrates.

The present findings were in consistent with earlier reports demonstrating that infusion temperature strongly influences the release of sugars and taste-active compounds in tea beverages (Komes *et al.*, 2010; Chiang *et al.*, 2020) [12, 4]. From a sensory perspective, increased reducing sugar content may contribute to mild sweetness and improved mouthfeel, which aligns with the higher sensory acceptability observed for floral green tea infusions.

3.2.2 Protein content

Protein content was also significantly higher in floral green tea infusions compared to the control. Hot floral infusion showed an increase in protein concentration from 15.55 mg g⁻¹ in the control to 28.27 mg g⁻¹, while cold floral infusion exhibited the highest protein content (38.33 mg g⁻¹). The

comparatively higher protein levels in cold floral infusions suggest that prolonged extraction time at ambient temperature might favoured the solubilization of flower-derived proteins and peptides. Edible flowers have been reported to contain notable levels of proteins that might have been released gradually during extended infusion (Navarro-González *et al.*, 2014) ^[17]. The lower temperature conditions of cold infusion may reduce protein denaturation allowing greater retention of soluble proteins. Similar observations had been reported for plant-based infusions where extraction duration played a more dominant role than temperature in protein recovery.

In addition, interactions between proteins and polyphenols may influence protein extractability. Mori *et al.*, 2010 ^[16] demonstrated that green tea catechins can form covalent and non-covalent complexes with proteins, potentially affecting their solubility and recovery. Zhang *et al.* (2015) ^[30] further reported that tea processing conditions significantly alter the functional properties and extractability of tea proteins. These interactions might partially explain differences observed between control and floral blends and hence, the presence of additional biomolecules from edible flowers modifies the infusion matrix.

3.2.3 Total phenolic content (TPC)

Total phenolic content was significantly higher in control green tea compared to floral green tea under both infusion methods. Hot control green tea exhibited the highest TPC (251.67 mg GAE g⁻¹), whereas hot floral green tea showed a reduced value of 161.34 mg GAE g⁻¹. A similar reduction was observed in cold infusions, with control green tea recording 194.67 mg GAE g⁻¹ and floral green tea showing 105.74 mg GAE g⁻¹. The decrease in TPC observed in floral blends may be attributed to a dilution effect, as a portion of green tea solids rich in catechins was replaced by floral material with a comparatively different phenolic profile. Additionally, complex formation between phenolic compounds and proteins or sugars introduced through edible flowers may reduce the availability of free phenolics detectable by the Folin-Ciocalteu assay (Preciado-Saldana *et al.*, 2019) ^[19].

Despite the reduction in TPC in floral green tea, hot infusion consistently resulted in higher phenolic extraction than cold infusion for both control and floral samples. This observation confirms the temperature-dependent nature of phenolic extraction, as higher temperatures enhance solubility and diffusion of phenolic compounds from plant matrices (Komes *et al.*, 2010; Chandrasekara & Shahidi, 2018) ^[12, 21]. These findings align with earlier reports emphasizing hot brewing as more effective for maximizing polyphenol yield in tea beverages.

3.2.4 Total tannin content (TTC)

Total tannin content followed trends similar to those observed for TPC, with control green tea exhibiting significantly higher tannin levels than floral green tea under both infusion conditions. Hot control green tea recorded the highest TTC (33.05 mg TAE g⁻¹), while hot floral green tea showed a reduced value of 22.87 mg TAE g⁻¹. Cold infusions followed a comparable pattern. The reduction in tannin content in floral green tea may be advantageous from a sensory perspective, as tannins are primarily responsible for bitterness and astringency in tea. Lower tannin levels may therefore contribute to the enhanced sensory

acceptability observed for floral blends. Similar reductions in tannin-associated astringency have been reported in herbal and floral tea blends, where the addition of non-tea botanicals moderated harsh sensory attributes (Hussain *et al.*, 2019) ^[9]. Variability in tannin content among different tea and herbal infusions emphasized that botanical composition and extraction conditions strongly influence tannin levels (Tinkilic and Uyanik, 2001) ^[26]. The present data suggest that edible flower fortification could effectively modulate tannin concentration while maintaining acceptable phytochemical levels.

3.2.5 Total flavonoid content (TFC)

Total flavonoid content was significantly higher in control green tea than in floral green tea for both hot and cold infusions. Hot control green tea exhibited the highest TFC (1.44 mg QE g⁻¹), while hot floral green tea showed a reduced value of 0.75 mg QE g⁻¹. Similar reductions were observed in cold infusions. Although hibiscus and marigold are known sources of flavonoids, the dominance of catechin-type flavonoids in green tea likely accounts for the higher TFC observed in control samples. Thermal degradation of certain flavonoids during infusion, as well as interactions with other phytochemicals, may further reduce detectable flavonoid levels in blended formulations (Fawwaz *et al.*, 2022) ^[6]. Manivannan *et al.*, (2021) ^[15] reported that flavonoid content in marigold petals varies widely depending on genotype and processing conditions, that might influence their contribution to blended infusions. Therefore, floral green tea exhibited lower TFC values but the presence of diverse flavonoid subclasses from edible flowers may still contribute to overall functional properties.

3.2.6 Total caffeoylquinic acid content (TCAC)

Caffeoylquinic acid content as analysed by molybdate assay demonstrated that hot control green tea contained highest (1.907 mg CGAE g⁻¹) and was decreased significantly in floral blends and cold infusions. Hot extraction consistently favoured higher TCAC values compared to cold extraction, confirming the influence of temperature on the recovery of hydrophilic CAC. Grujic-Letic *et al.*, (2015) ^[8] reported that green tea contains substantial amounts of caffeoylquinic acids that was efficiently extracted under hot brewing conditions. Similarly, da Silveira *et al.*, (2017) ^[5] demonstrated that higher temperatures significantly enhance chlorogenic acid extraction in tea beverages. The reduced TCAC observed in floral green tea may reflect partial replacement of tea material with floral components and potential binding interactions with proteins or carbohydrates.

The study suggested that value addition of green tea with hibiscus and marigold petals offers a balanced functional beverage with substantial bioactive potential, supporting its suitability for functional beverage development.

4. Conclusion

The present investigation demonstrated that value addition of green tea (*Camellia sinensis*) with edible hibiscus (*Hibiscus rosa-sinensis*) and marigold (*Tagetes erecta*) petals significantly enhanced both the sensory and biochemical attributes of the resulting beverage. Incorporation of edible flowers improved key sensory parameters including appearance, color, aroma, taste, flavor, and overall acceptability, with hot infusion consistently

yielding superior sensory scores compared to cold infusion. These improvements can be attributed to the contribution of natural pigments, volatile compounds and taste-modulating components derived from the floral materials. Phytochemical analysis revealed that floral green tea infusions exhibited significantly higher reducing sugar and protein contents than control green tea under both infusion conditions. The increase in these components likely contributed to enhanced sweetness, mouthfeel, and overall palatability of the floral blends. In contrast, moderate reductions were observed in polyphenol-related compounds such as total phenolics, tannins, flavonoids, and caffeoylquinic acids in floral green tea compared to the control. These reductions may be attributed to dilution effects, phytochemical interactions and partial complex formation between tea polyphenols and flower-derived biomolecules.

Despite the observed decrease in certain phenolic constituents, floral green tea retained appreciable levels of bioactive compounds, indicating that functional potential was not compromised. Furthermore, infusion temperature played a critical role in phytochemical extraction, with hot infusion consistently enhancing the recovery of bioactive compounds compared to cold infusion. This highlights the importance of extraction conditions in optimizing both sensory quality and phytochemical yield. Overall, the findings suggest that edible flower fortification represents a promising strategy for developing value-added green tea beverages that combine improved sensory appeal with functional attributes. The incorporation of hibiscus and marigold petals offers a balanced formulation that enhances consumer acceptability while maintaining substantial bioactive content. Such floral green tea formulations may serve as innovative functional beverages catering to the growing consumer demand for natural, health-oriented, and sensorially appealing drink options.

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