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Evaluation of sensory, mineral and phytochemical properties of herbal tea made from moringa leaves and seeds, flavored with ginger and garlic

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Abstract

This study evaluated the sensory, mineral, and phytochemical properties of herbal teas formulated from *Moringa oleifera* leaves and seeds, flavored with ginger and garlic. The four components were dried, milled into powder, and formulated into five tea blend ratios. The samples, which are MMGG1 (86:10:3:1), MMGG2 (82:14:3:1), MMGG3 (78:18:3:1), MMGG4 (74:22:3:1), and MMGG5 (70:26:3:1), were developed using a mixture design and assessed for sensory acceptability, mineral composition (calcium, iron, potassium, phosphorus), and phytochemical contents (tannins, phenols, flavonoids, saponins). MMGG1 emerged as the most preferred sample across all sensory attributes, while MMGG3 and MMGG5 were the least accepted in overall mouthfeel and taste. Significant differences ($p < 0.05$) were observed among samples for all sensory and mineral properties. MMGG5 recorded the highest calcium (28.58 mg/100 g), potassium (24.46 mg/100 g), and phosphorus (14.75 mg/100 g), whereas MMGG3 had the highest iron (2.86 mg/100 g). Phytochemical analysis revealed moderate levels of flavonoids, phenols, and saponins across all blends, with MMGG3 exhibiting the highest flavonoid content (1.43 mg/g). The inclusion of both moringa seeds and leaves with functional spices resulted in mineral-dense, antioxidant-rich herbal teas. These findings suggest potential for developing consumer-acceptable functional beverages with enhanced nutritional and health benefits.

Keywords: Antioxidants, functional beverage, garlic powder, ginger powder, herbs.

INTRODUCTION

Herbs, which are primarily aromatic plant leaves, encompass a range of species like moringa, basil, bay leaves, dill leaves, marjoram, tarragon, and thyme. Additionally, certain vegetables such as onion, garlic, shallot, and celery contribute to culinary flavor and aroma (Adeeyo *et al.,* 2021). Herbal teas, beverages traditionally brewed from the infusion of leaves, seeds, roots, flowers, or other plant materials, are widely consumed for their health-promoting properties and cultural significance. Unlike caffeinated beverages derived from *Camellia sinensis*, herbal teas are caffeine-free and often deliver functional benefits such as antioxidant, anti-inflammatory, and antimicrobial effects (Herrera *et al*., 2022). The history and cultural significance of herbal teas reflect the diverse ways in which societies have used these infusions for both medicinal and social purposes (Herrera *et al*., 2020).

Moringa oleifera, often referred to as the miracle tree, has garnered attention recently for its exceptional nutritional and medicinal attributes. While the leaves are rich in calcium, potassium, iron, and antioxidants such as flavonoids, phenolic compounds, ascorbic acid, and carotenoids (Bello *et al*., 2022), the seeds, though less studied in beverage formulations, are noted for their high protein content, phytochemicals, and detoxifying properties (Tijjani *et al*., 2023). Studies suggest that moringa seed extracts possess antimicrobial, antidiabetic, and lipid-lowering effects, making them a valuable yet underutilized component in functional food development (Abubakar *et al*., 2021).

Ginger (*Zingiber officinale*) is known for its anti-inflammatory and gastrointestinal benefits, while garlic (*Allium sativum*) provides cardioprotective and antimicrobial effects due to its rich organosulfur content (Okonkwo *et al*., 2023; Yekeen *et al*., 2022).

The integration of moringa seeds with leaves in tea formulation offers a synergistic nutritional advantage, combining leafy phytochemicals with the seed's dense mineral profile. Furthermore, the inclusion of ginger and garlic, both widely used in traditional medicine, enhances the tea's functional potential. Although moringa leaf-based herbal teas are common, very few studies have incorporated moringa seeds, particularly in combination with ginger and garlic, into a palatable tea product. Incorporating indigenous functional ingredients like moringa, ginger, and garlic into consumer products is a cost-effective strategy to combat malnutrition and chronic diseases (Adeoye and Umeh, 2024). This blend, if optimized for taste and nutritional profile, may appeal to health-conscious consumers and provide new opportunities in the functional beverage market. Therefore, this study evaluated the sensory characteristics, mineral composition, and phytochemical properties of herbal teas made from *Moringa oleifera* leaves and seeds, flavored with ginger and garlic. The findings in this research would help explore the potential of this novel formulation for health promotion and commercial development.

MATERIALS AND METHOD

Sources of Raw Materials

Fresh moringa leaves and seeds were obtained from a garden in Amaenyi Awka, while fresh garlic and ginger were purchased from Eke-Awka market, Awka, Anambra State, Nigeria. The samples were transferred under hygienic conditions to the Department of Food Science and Technology Laboratory, Nnamdi Azikiwe University, Awka, for processing.

Experimental Design

A five-treatment mixture design was employed to produce herbal tea blends using varying proportions of moringa leaves and seeds, with fixed quantities of ginger and garlic (3% and 1%, respectively). The five formulations (MMGG1 to MMGG5) are presented in Table 1. They were produced and analyzed in triplicate (n = 3).

Sample Preparation

The ginger roots were washed, sorted, peeled, diced, and dried using a microwave oven at a temperature of 60°C for 4 hours. The dried samples were ground into fine powder using an electric blender. The garlic was removed from the cloves, peeled, sliced, and dried (microwave oven) at 60°C for 20 minutes, after which the samples were ground into fine powder using an electric blender. Moringa leaves and seeds were dried using a cabinet tray dryer at 60°C for 5 minutes and 12 minutes, respectively. The dehydrated seeds and leaves were ground into fine powders, kept in their respective airtight Ziploc bags, and stored at 4°C until further use. The process flowcharts are shown in Figures 1 and 2.

Sensory Analysis

Sensory evaluation was conducted by 25 untrained panelists using a 9-point hedonic scale (9 - like extremely, 8 - like very much, 7 - like moderately, 6 - like slightly, 5 - neither like nor dislike, 4 - dislike slightly, 3 - dislike moderately, 2 - dislike very much, and 1 - dislike extremely). The panelists, composed of males and females, evaluated the sensory characteristics of appearance, aroma, mouthfeel, taste, aftertaste, and overall acceptability of the herbal tea blends. Each panelist sat in an isolated place (booth) to limit any disturbances. All samples were served warm in coded cups and presented in a randomized arrangement.

Mineral Analysis

Determination of calcium

Calcium was determined by a procedure using an Agilent FS240AA Atomic Absorption Spectrophotometer (AAS), according to the method of APHA, 2019 (American Public Health Association). The sample was prepared by digesting 2 g of the sample with 20 ml of acid mixture (HNO_3, perchloric acid, H_2SO_4), and the digest was diluted to 100 ml. A calibration curve was then plotted, calcium analysis was performed using AAS at 422.7 nm, and the calcium concentration was calculated using;

$$\text{Calcium (mg/L)} = \frac{A \times \frac{100}{2}}{S}$$

Where;

A = Absorbance of sample
(mg/L) = conversion factor
S = Sensitivity (or Slope) of calibration curve
(100 ml /2 g) = Dilution factor

Table 1. Composition of the Herbal Tea Samples.

Sample code	Composition (%)			
	Moringa leaves powder	Moringa seeds powder	Ginger powder	Garlic powder
MMGG1	86	10	3	1
MMGG2	82	14	3	1
MMGG3	78	18	3	1
MMGG4	74	22	3	1
MMGG5	70	26	3	1

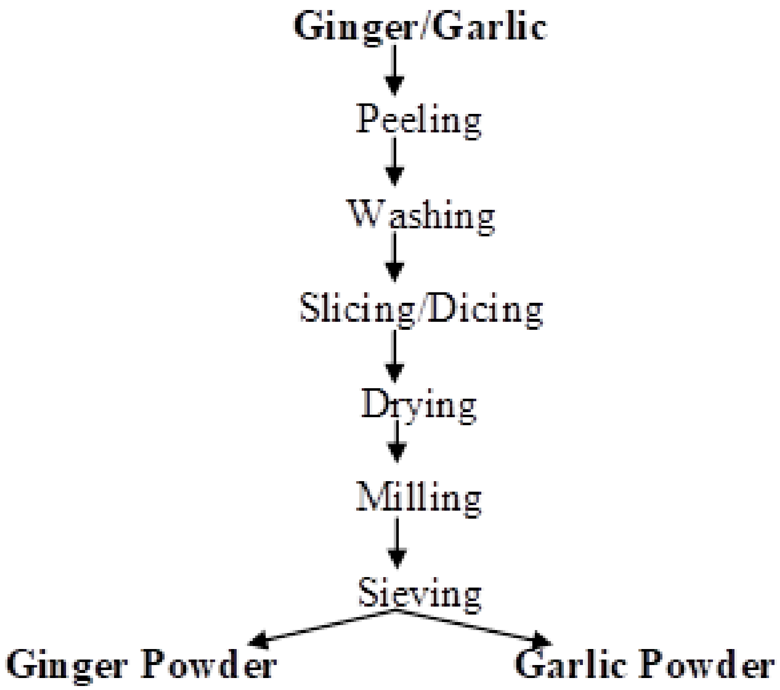

Figure 1. Production of ginger and garlic powder Source: Sekwati-Monang (2011).

Determination of iron

The sample was prepared by digesting 2 g of the sample with 20 ml of acid mixture (HNO_3, perchloric acid, H_2SO_4) and diluted to 100 ml. A calibration curve was plotted; iron analysis was performed using AAS at 248.3 nm, and the concentrations were measured using;

Iron (mg/L) = $\frac{A-D}{S}$

Where;
A = Absorbance of sample
S = Sensitivity (or Slope) of calibration curve3
D = Dilution factor (100 mL /2 g)

Determination of potassium

Potassium was determined using an Agilent FS240AA Atomic Absorption Spectrophotometer according to the method of APHA 2019 (American Public Health Association). The sample was prepared by digesting 2 g of the sample with 20 ml of acid mixture (HNO_3, perchloric acid, H_2SO_4), and the digest was diluted to 100 ml. A calibration curve was then plotted, potassium analysis was performed using AAS at 766.5 nm, and the concentrations were calculated using;

Potassium (mg/L) = $\frac{A-D}{S}$

Where;

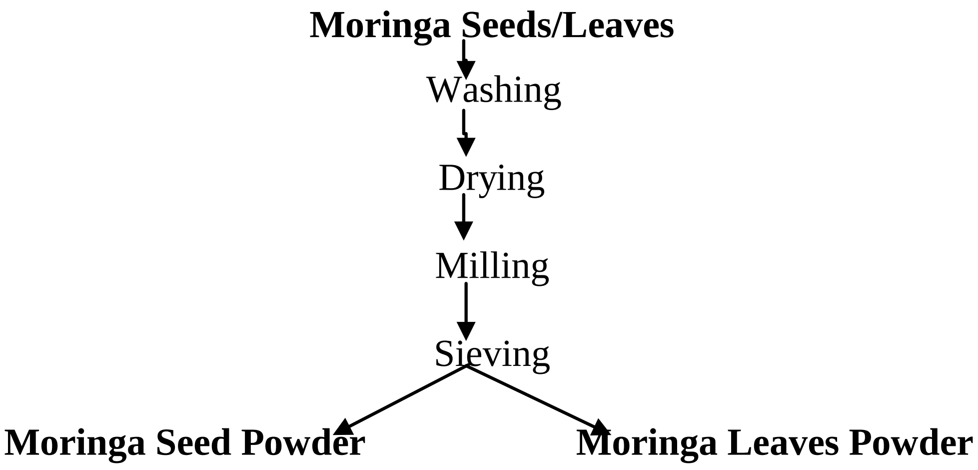

Figure 2. Production of Moringa leaves and seeds powder Source: Bolarrinwa (2017).

A = Absorbance of sample
S = Sensitivity (or Slope) of calibration curve
D = Dilution factor (100 mL/2 g)

Determination of phosphorus

Phosphorus was determined by a procedure using an Agilent FS240AA Atomic Absorption Spectrophotometer Absorption according to the method of APHA 2019 (American Public Health Association). The sample was prepared by digesting 2 g of the sample with 20 ml of acid mixture (HNO_3, perchloric acid, H_2SO_4), and the digest was diluted to 100 ml. A calibration curve was then plotted. Phosphorus analysis was performed using AAS at 661 nm (or 395 nm) after formation of the phosphomolybdate complex, and the concentrations were calculated using;

Phosphorus (mg/L) = $\frac{A-D}{S}$

Where;

A = Absorbance of sample
S = Sensitivity (or Slope) of calibration curve
D = Dilution factor

Determination of Phytochemicals

Determination of total flavonoids

Total flavonoid content was determined using the AOAC (2010) method. About 5 g of the samples was used. The sample was added to 50 mL to 2 M HCl at room temperature. The solution was boiled for 30 minutes with a water bath and allowed to cool before being filtered through Whatman. filter paper No. 40, 10 ml of ethyl acetate was added to the filtrate and was filtered again with a weighed filter paper. The filter paper was oven-dried, cooled, and weighed again. The experiment was repeated two more times, and the average was calculated. The total flavonoid content was calculated using;

% Flavonoids = $\frac{W_1 - W_2}{\text{Weight of sample}} \times 100$

Where;

W_2 = Weight of empty filter paper
W_1 = Weight of paper + flavonoids extract (residue)

Determination of total phenols

The Folin-Denis spectrophotometric method was used. The powdered tea sample was prepared by dissolving 1-2 g of the samples in 100 ml of distilled water. The mixture was stirred well and then filtered through a 0.45 um filter paper to remove insoluble particles. Then the sample was added with FCR: 0.5 ml of the tea extract was mixed with 0.5 ml of FCR in a test tube. The phenolic content was calculated using;

Total Phenol (mg GAE/100 mL) = $\frac{A \times C \times D}{E \times 100}$

Where;

A = Absorbance of test sample (at 760 nm)
C = Concentration of standard solution (mg/mL)
D = Dilution factor
E = Absorbance of standard solution (at 760 nm)

Determination of tannins

The Folin-Denis spectrophotometric method was used. One gram of the sample was weighed and dispersed in distilled water and agitated. The solution was left to stand for 30 min at room temperature while being shaken every 5 min. At the end of the 30 min, the solution was centrifuged and the extract was gotten. 2.5 ml of the supernatant (extract) was dispersed into a 50 ml volumetric flask. Similarly, 2.5 ml of standard tannic acid solution were dispersed into a separate 50 ml flask. A 10 ml Folin-Denis reagent was measured into each flask, followed by 2.5 ml of saturated Na_2CO_3 solution. The mixture was diluted to the mark in the flask (50 ml) and incubated for 90 min at room temperature. The absorbance was measured at 250 nm in a spectrophotometer. Readings were taken with the reagent at blank zero. The tannin content was calculated using;

$$\% \text{ Tannins} = \frac{A \times C \times D}{E \times F \times 100}$$

Where;

A = Absorbance of test sample (at 765 nm)
C = Concentration of standard solution (mg/mL)
D = Dilution factor
E = Absorbance of standard solution (at 765 nm)
F = Volume of extract analyzed (mL)

Determination of saponins

Saponin determination was carried out according to the AOAC (2010) method. Five grams of the sample were boiled with 50 ml of 20% ethanol in a water bath for 1 min and filtered while still hot. The filtrate was collected and heated for 30 minutes in 40 ml of ether and then poured into a separating funnel. The lower part of the filtrate in the separating funnel was collected, 50 ml of n-butanol was added, and the upper layer was collected while the lower part was discarded. The filtrate was evaporated to dryness using a steam bath at 700°C in an oven and then cooled and weighed. The experiment was repeated twice, and the average was calculated. The saponin content was determined by difference and calculated as a percentage of the original sample using;

$$\% \text{ Saponins} = \frac{W_2 - W_1}{Weight\ of\ sample} \times 100$$

Where,

W_2 = Weight of dish + sample, and
W_1 = Weight of evaporating dish

Statistical Analysis of Data

The various data obtained during the study were subjected to statistical analysis using Analysis of Variance (ANOVA) with Completely Randomized Design (CRD) to detect significant differences between treatments, and Duncan's multiple range test was used to separate means where significant differences existed at $p < 0.05$.

RESULTS AND DISCUSSION

Sensory Properties

The herbal tea samples exhibited a mottled dark green and gray colour with a characteristic spicy flavour. This was most likely attributed to the corresponding characteristics of its formulation components. Sensory evaluation is significant in the production of consumable products in order to gauge consumer acceptance (Akujobi et al., 2018).

The results of the sensory evaluation are shown in Table 2. As can be seen in the table, the mouth feel of each sample varied across the blends in the range of 4.76 - 7.72, with sample MMGG1 (86:10:3:1) being the highest and sample MMGG3 (78:18:3:1) being the lowest. There was a significant difference ($p < 0.05$) between sample MMGG1 and sample MMGG4 (74:22:3:1) and other samples of varying ratios. This could be attributed to the astringent taste of moringa seed, which was more pronounced in the ones having higher ratios of moringa seed.

The aroma score fell within the range of 4.9 and 7.4, with sample MMGG1 being the highest and sample MMGG3 the lowest. There was a significant difference ($p < 0.05$) between samples MMGG1 and MMGG4 and the other samples. This pattern was similar to that noticed for mouth feel and is probably influenced by the high moringa seed ratio. The pattern, however, was not consistent.

The sensory evaluation results in Table 2 revealed MMGG1 to be the most acceptable in taste, aroma, and appearance, likely due to its balanced moringa leaf-to-seed ratio, which reduced bitterness while enhancing flavor with ginger and garlic. This aligns with the findings of Udeh *et al*. (2023), who found optimal acceptability at lower moringa seed inclusion at 10–15%. MMGG3 and MMGG5, with the higher seed contents, scored lower, possibly due to increased bitterness and astringency caused by elevated amounts of moringa seeds. This observation supports Obiorah and Oyetayo (2022), who found that excessive inclusion of *Moringa* seed (> 20%) in beverages negatively affected consumer liking. There was a significant difference ($p < 0.05$) between the samples except for samples MMGG1 and MMGG4, which had no significant difference ($p > 0.05$).

A study carried out by Yang *et al*. (2020) showed better acceptance of herbal tea flavored with garlic and ginger. The appearance rating for the samples ranged from 5.32 to 7.60, with sample MMGG1 being the highest and

Table 2. Sensory Properties of the Herbal Teas.

Sample	Mouthfeel	Aroma	Taste	Appearance	After taste	General acceptability
MMGG1	7.72^{a} ±1.14	7.48^{a} ±0.71	7.56^{a} ±1.12	7.60^{a} ±1.29	7.48^{a} ± 0.87	8.04^{a} ± 0.68
MMGG2	4.88^{b} ±1.48	5.44^{b} ±1.61	5.32^{b} ±1.93	5.92^{b} ±1.53	4.48^{c} ± 1.29	5.20^{c} ± 1.12
MMGG3	4.76^{b} ± .33	4.92^{b} ±1.38	4.80^{b} ±1.47	5.56^{b} ±1.58	3.88^{c} ± 1.42	4.40^{c} ± 1.41
MMGG4	7.20^{a} ±1.22	7.20^{a} ±0.96	6.76^{a} ±1.23	6.88^{a} ±1.62	6.24^{b} ± 1.61	7.00^{b} ± 1.47
MMGG5	5.48^{b} ±1.39	5.28^{b} ±1.57	4.72^{b} ±1.40	5.32^{b} ±1.38	4.60^{c} ± 1.96	4.88^{c} ± 1.96

Means with the same superscript along a particular column showed no significant difference at ($p < 0.05$). Values are means ± Standard deviation.

sample MMGG5 the lowest. There was a significant difference ($p < 0.05$), though without a definite pattern.

Aftertaste also varies across the blends, ranging from 3.88 to 7.48, with sample MMGG1 (86:10:3:1) being the highest and sample MMGG3 the lowest. There was a slight significant difference ($p < 0.05$) between the samples.

For general acceptability, Gbadegesin et al. (2017) reported better overall acceptability in herbal tea with 25% Moringa seed. Acceptability varied across the blends according to Table 2, and they ranged from 4.40 to 8.04, with sample MMGG1 being the highest and sample MMGG3 being the lowest. There was a significant difference ($p < 0.05$) between samples MMGG1 and MMGG4; however, no significant difference ($p > 0.05$) was observed for the other samples. These results suggest that moderate inclusion of moringa seeds (10–14%), alongside fixed ginger and garlic levels, yields a product with optimal sensory properties suitable for market introduction.

Mineral Content

Herbal tea flavoured with garlic and ginger had higher mineral values than non-flavoured herbal tea, as can be seen in Table 2. This is most likely attributed to the high mineral content of the herbal tea components and their possible synergistic effects. Flavoured herbal tea with garlic and ginger contains increased calcium (Akujobi et al., 2018).

According to Table 3, calcium varies across the blends, ranging from 17.62 to 28 mg, with sample MMGG5 being the highest and sample MMGG2 being the lowest. There was significant difference ($p < 0.05$) among the samples.

For iron content, the samples varied across the blends and ranged from 1.76 to 2.86 mg, with sample MMGG3 being the highest and sample MMGG5 being the lowest. These findings support Olorunfemi et al. (2022), who highlighted the iron-enriching potential of Moringa oleifera seed powder in food formulations. There was a significant difference ($p < 0.05$) between each sample across the blends.

From the results in Table 3, the herbal tea is rich in potassium. The potassium content varied across the blends, ranging from 11.96 to 24.46 mg, with sample MMGG5 being the highest and sample MMGG4 being the lowest. All the samples of various blends are significantly different ($p < 0.05$).

Comparatively, all blends exceeded the calcium and potassium levels reported by Bello et al. (2022) in standard herbal teas, indicating that the combination of moringa with spices like ginger and garlic may offer a synergistic micronutrient enhancement. Phosphorus was in the range of 9.56 - 14.75 mg, and there was a significant difference ($p < 0.05$) between the samples.

Mineral composition varied significantly among the blends. MMGG5 showed the highest calcium, potassium, and phosphorus, while MMGG3 had the highest iron content (2.86 mg/100 g). These findings support Olorunfemi et al. (2022), affirming the mineral richness of moringa seed-based formulations.

Phytochemicals Content

The phytochemical screening of the herbal tea blend indicated the presence of secondary metabolites, as shown in Table 4.

The tannin content varied across the blends, ranging from 0.06 to 0.07 mg, with sample MMGG2 being the highest and sample MMGG1 being the lowest. There was no significant difference ($p < 0.05$) between the samples.

Phenolic content varied across the blends, ranging from 0.65 to 0.66 mg, with sample MMGG1 being the highest and MMGG5 being the lowest. However, the total phenolic content showed no significant difference ($p < 0.05$) across the herbal tea blends. According to a study by Adeoye *et al.* (2019), the phenolic content of herbal tea flavored with garlic and ginger increased as the spice concentration increased, implying that the phenolic content of the flavored herbal tea production had an additive or synergistic effect. Meanwhile, in this case, they were held constant, which may be the cause for no significant difference in their content according to the results in Table 4.

Table 3. Mineral Content of the Herbal Teas.

Sample	Ca (mg/100 g)	Fe (mg/100 g)	K (mg/100 g)	P (mg/100 g)
MMGG1	20.04^{d}±0.01	2.17^{c}±0.02	13.70^{d}±0.02	12.25^{b}±0.01
MMGG2	17.62^{e}±0.01	1.92^{d}±0.01	21.96^{b}±0.01	9.46^{d}±0.01
MMGG3	25.52^{b}±0.01	2.86^{a}±0.01	20.58^{c}±0.01	10.22^{c}±0.01
MMGG4	23.58^{c}±0.01	2.81^{b}±0.01	11.96^{e}±0.01	12.25^{b}±0.01
MMGG5	28.58^{a}±0.01	1.76^{e}±0.01	24.46^{a}±0.01	14.75^{a}±0.01

Means with the same superscript along a particular column showed no significant difference at ($p < 0.05$). Values are means ± Standard deviation.

Table 4. Phytochemicals Content of the Herbal Teas.

Sample	Tannin (mg/g)	Phenols (mgGAE/g)	Flavonoids (mgQE/g)	Saponins (mg/g)
MMGG1	0.06^{a} ± 0.00	0.66^{a} ± 0.00	1.39^{b} ± 0.00	153.67^{a} ± 1.53
MMGG2	0.07^{a} ± 0.00	0.66^{a} ± 0.00	1.30^{d} ± 0.01	35.67^{c} ± 2.08
MMGG3	0.07^{a} ± 0.00	0.66^{a} ± 0.00	1.43^{a} ± 0.01	16.33^{d} ± 1.15
MMGG4	0.06^{a} ± 0.00	0.66^{a} ± 0.00	1.35^{c} ± 0.01	15.00^{d} ± 1.00
MMGG5	0.06^{a} ± 0.00	0.65^{a} ± 0.00	1.21^{e} ± 0.01	46.33^{b} ± 1.53

Means with the same superscript along a particular column showed no significant difference at ($p < 0.05$). Values are means ± Standard deviation.

Key

MMGG1 = (Moringa leaf 86 %, Moringa seed 10 %, Ginger 3 % and Garlic 1 %)
MMGG2 = (Moringa leaf 82 %, Moringa seed 14 %, Ginger 3 % and Garlic 1 %)
MMGG3 = (Moringa leaf 78 %, Moringa seed 18 %, Ginger 3 % and Garlic 1 %)
MMGG4 = (Moringa leaf 74 %, Moringa seed 22 %, Ginger 3 % and Garlic 1 %)
MMGG5 = (Moringa leaf 70 %, Moringa seed 26 %, Ginger 3 % and Garlic 1 %)

Moringa seeds and leaves used in preparing the herbal tea are rich in flavonoids. This is responsible for the high antioxidant activity seen in the herbal tea, which correlates with the high ability of the tea to scavenge free radicals. Furthermore, the ferric reducing ability of the herb was highest in the herbal tea, possibly due to its high flavonoid content. Flavonoids varied across the blends in the range of 1.21 - 1.43 mg, with sample MMGG3 being the highest and sample MMGG5 being the lowest. The high flavonoid content suggests a potential antioxidant advantage, as flavonoids have been linked to reduced oxidative stress and improved cardiovascular health (Ajiboye *et al*., 2023). There was a significant difference ($p < 0.05$) between each sample except for sample MMGG3 and sample MMGG2, which had no significant difference ($p > 0.05$).

Saponin content varied across the blends and ranged from 1.53 to 46.33 mg, with MMGG5 being the highest and sample MMGG1 the lowest. There was a significant difference ($p < 0.05$) among the samples, even though there was none ($p > 0.05$) between samples MMGG3 and MMGG4. Saponins help in protecting the plant against microbes and fungi and may also enhance nutrient absorption and aid in animal digestion (Pagano, 2021). The presence of saponin is known for cholesterol-lowering and immune-boosting effects (Ishola & Mohammed, 2021).

CONCLUSION

This study demonstrated the potential of developing a functional herbal tea using Moringa oleifera leaves and seeds, flavoured with ginger and garlic. Among the five blends evaluated, MMGG1 (86:10:3:1) was the most preferred based on sensory attributes, while sample MMGG3 (78:18:3:1) was the least liked. Sample MMGG5 showed the highest mineral content, particularly in calcium, potassium, and phosphorus. MMGG3, in turn, had the highest iron and flavonoid levels, indicating antioxidant potential.

All blends were found to contain essential minerals (such as calcium, iron, potassium, and phosphorus), which are important for bone health, immune function, and overall well-being, and phytochemicals (such as flavonoids, saponins, phenols, and tannins) that contribute to immune enhancement, antioxidant defense, and cardiovascular support. The results suggest that combining moringa seeds and leaves with functional spices can yield a palatable, nutrient-rich beverage suitable for health-conscious consumers.

These findings suggest that the herbal tea blends offer both a pleasant sensory experience and notable health advantages, making them well-suited for the functional beverage market. Given the growing market for plant-based functional drinks, the optimized blend of moringa, ginger, and garlic presents a viable product for both nutritional intervention and commercial development. Future research may explore storage stability, consumer behavior, and bioavailability of key nutrients to support large-scale production.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the work reported in this manuscript. No funding was obtained or used for this research.

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