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Research

Formulation and assessment of a herbal tea powder

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Background
Studies have shown that tea provides numerous benefits. Herbal teas are prepared with medicinal plants, herbs and spices and often drunk worldwide. They usually contain antioxidants, phenolic compounds, flavonoids, alkaloids, saponins, carotenoids and other bioactive substances. They have shown potential in improving the diet-related non-communicable diseases. In Cameroon, the prevalence of these diseases, including hypertension, obesity, type 2 diabetes, coronary heart disease and some cancers, are on the rise. Cameroon has a wide variety of medicinal plants, herbs and spices that have not been explored and thus the present study investigates the formulation, sensory acceptability, and quality assessment of a herbal tea with possible health benefits.

Objective
To formulate five herbal tea powders using selected three herbs and spices traditionally thought to have health benefits. To analyze their physicochemical and phytochemical properties. To determine their nutritional and microbial properties. To assess their sensory characteristics (taste, aroma, color, and overall acceptability) through consumer evaluation.

Methods
An experimental study design was used and the study was carried out in the food science laboratory of Catholic University of Cameroon, Bamenda. Roselle (Hibiscus Sabdaria), turmeric (Curcuma Longa) and cinnamon (Cinnamomum) were processed to powder form to form. They were combined to create the following formulations: *Sample A = 100% Cinnamon Powder, Sample B = 70% Cinnamon, 20% Roselle, 10% Turmeric, Sample C = 50% Cinnamon, 40% Roselle, 10% Turmeric, Sample D= 40% Cinnamon, 50% Roselle, 10% Turmeric, Sample E = 20% Cinnamon, 70% Roselle, 10% Turmeric.* Qualitative and quantitative phytochemical analysis, nutritional analysis and microbial analysis were conducted on all formulations. Sensory evaluation of the tea formulations was carried out using a 9-point hedonic scale. Data were analyzed using ANOVA in SPPS version 15. A value of <0.05 was regarded as statistically significant.

Results
There were significant differences for their physical, nutritional, phytochemical and sensory properties. There was no significant difference ($p>0.05$) in microbial load. Moisture content ranged from 10.1 to 11.4%, ash content 1.62 to 2.10 g/100g, fiber content 0.79 to 1.17g/100g, and vitamin C content 8.8 to 17.6 mg/100g. The phytochemicals: alkaloid, flavonoids and saponin ranged respectively from 2.67 to 6.11 mg/100g, 5.86 to 7.93 mg/100g, and 0.53 to 1.85 mg/100g. The bacteria count ranged from 2 to 11 CFU/mL. All the herbal tea samples were accepted by the sensory panellist for appearance, aroma, taste, texture and general acceptability.

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Conclusions

Sample D contained higher levels of nutrients and bioactive compounds. These can support overall health and in managing NCDs. Many NCDs are linked to oxidative stress and since sample D has strong antioxidant properties, it could help reduce oxidative damage thus improve the diet related non-communicable diseases.

INTRODUCTION

Herbal teas have been consumed for centuries worldwide for their potential health benefits. They are rich in nutrients and bioactive compounds such as polyphenols, flavonoids and antioxidants (Mao et al. 2017). With increasing interest in natural remedies, especially herbs, the formulation of a herbal tea powder offers a convenient and effective way to harness these benefits ensuring longer shelf life and ease of preparation.

Several studies have explored the formulation and assessment of herbal teas using different herbs and spices of known health benefits. Research has shown that herbal teas formulated from plants such as *Camellia sinensis, hibiscus sabdariffa, moringa oleifera, Cinnamomum and zingiber officinale* exhibit significant antioxidant, anti-inflammatory and metabolic health benefits (Montalvo-Gonzalez, 2022; Anggraini and Kartinah, 2021). Herbal tea powders containing antioxidants (Mao et al. 2017) have demonstrated potential in reducing oxidative stress which is a key contributor to the diet related non-communicable diseases and their and phytochemicals contribute as well (Mathivha et al. 2020). With the high prevalence of diet related non-communicable diseases in Cameroon (Akob et al. 2023), there is need to explore this area of herbal teas. In addition to the medicinal properties, the physicochemical properties of herbal teas such as the pH, bulk density, dispersibility and wettability are important in determining their quality and shelf life. Studies have also shown that proper and correct methods of formulation significantly impact the retention of desirable sensory attributes (Mathivha et al. 2020).

Cinnamon, a widely used spice known for its antioxidants and anti-inflammatory properties, has been shown to regulate blood glucose levels and improve insulin sensitivity (Hewlings & Kalman 2017). Turmeric contains a bioactive compound called curcumin and studies have indicated that curcumin supplementation can aid in weight loss by reducing adipose tissue inflammation and improving metabolic parameters (Hewlings & Kalman 2017). Roselle, known for its vibrant red color, is a tropical plant widely used as a medicinal herb. It contains phytochemicals such as polyphenols and anthocyanins that possesses antioxidant and anti-inflammatory properties (Montalvo-Gonzalez, 2022).

Traditional herbal teas made from local plants are more commonly consumed in Cameroon than commercially available tea products, however the consumption of herbal teas in Cameroon has declined in recent years; most consumers do not like their taste (Fongnzossie et al. 2021). A recent survey among 307 Cameroonian adults found that 89% had taken one of the most common traditional teas (*Moringa oleifera, Zanthoxyllum heitzii* and *Vernonia amygdalina*) at least once (Nchang et al. 2023). The tea taken by 70% of the users had a bad or bitter taste and 52.2% of them were uncomfortable with this taste.

Sensory evaluation studies have shown that factors such as taste, aroma, color and overall acceptance influence consumer preferences (Malongane et al. 2020). Herbal tea formulations with appealing sensory attributes are more likely to be consumed and integrated into daily diets (Malongane et al. 2020).

Therefore, the present study aimed to formulate a herbal tea powder based on cinnamon, turmeric, and roselle, and assess it based on physicochemical, phytochemical, nutritional, and microbial properties and to evaluate its sensory acceptability.

METHODS

RESEARCH DESIGN

A mixed method approach was used for the study, incorporating both quantitative and qualitative methods. The study also involved a descriptive experimental design where 5 samples were subjected to physical, phytochemical, nutritional, microbial and sensory analysis. A trained sensory analysis panel (n= 45) was used to evaluate the samples.

SAMPLE PROCUREMENT

Dried hibiscus roselle commonly known in Cameroon as "*folere",* fresh turmeric and cinnamon sticks were purchased from the Bamenda food market, North West Region, Cameroon.

SAMPLE PREPARATION

PRODUCTION OF ROSELLE (Hibiscus sabdaria) POWDER

The purchased Roselle (dry) was spread out in a single layer on a baking sheet and placed in a preheated oven set to 70°C.The dried Roselle were removed from the oven once they were crisp and brittle to the touch; then it was milled to semi powder form. It was then sieved using a 0.5 mm sieve to remove the powder and then with a 1 mm sieve to obtain the particles used for the study.

PRODUCTION OF TURMERIC (Curcuma longa) POWDER

Turmeric rhizomes were sorted and washed without removing their skin, rinsed and then blanched in hot water at a temperature of 70°C for approximately 5 minutes to help minimize nutrient loss (Park et al. 2022; Uchechukwu, 2020). The blanched turmeric rhizomes were cooled in cold water to retain a vibrant color (El-saadony et al. 2023). The turmeric rhizomes were then oven dried at 70 °C for 24 hours. Once the turmeric rhizomes were dried, they were milled and sieved using a 0.5 mm sieve to separate the powdered particles and then with a 1mm sieve to obtain the particles used for the study.

PRODUCTION OF CINNAMON (Cinnamomum) POWDER

Cinnamon sticks were oven dried at 75°C for 30 minutes to remove excess moisture and extend shelf life. They were then milled into powder and sieved using a 0.5 mm sieve to separate the powdered particles and then with a 1mm sieve to obtain the particles used for the study.

SAMPLE FORMULATION

Roselle, Turmeric and cinnamon powders were blended in varying proportions to create 5 different samples. A preliminary study was carried out to select the five samples for analysis (Mulak et al. 2021).

Sample A = 100% Cinnamon Powder
Sample B = 70% Cinnamon, 20% Roselle, 10% Turmeric
Sample C = 50% Cinnamon, 40% Roselle, 10% Turmeric
Sample D= 40% Cinnamon, 50% Roselle, 10% Turmeric
Sample E = 20% Cinnamon, 70% Roselle, 10% Turmeric

PHYSICAL PROPERTIES OF TEA

DETERMINATION OF BULK DENSITY

The bulk density of the tea blends was determined using the method described by Khanum et al. (2017). The tea sample (5 g) was poured into a (10 mL) dry measuring cylinder and the volume was recorded for the loose bulk density. The bottom of the cylinder was tapped 70 times on the laboratory table and the volume was recorded for packed bulk density. The bulk density was calculated as:

$$Bulk\ density\ \left({}^{g}/_{cm}{}^{3}\right) = \frac{Weight\ of\ sample}{Volume\ of\ sample\ after\ tapping}$$

DETERMINATION OF pH

The pH of the samples was determined with the help of pH meter (Model PHS-3C). The pH was determined according to AOAC (2005).

DISPERSIBILITY

Dispersibility refers to the ability of a substance, mostly powders, to disperse uniformly throughout another medium, such as a liquid without forming lumps (Mulak et al. 2020). Ten grams (10g) of tea samples were weighed into 100ml measuring cylinder and distilled water was added to reach a volume of 100 ml, stirred vigorously, and allowed to settle for 3hrs. The volume of settled particles was recorded and subtracted from 100. The difference was reported as % dispersibility (Mulak et al. 2020).

WETTABILITY

Wettability in food refers to the ability of a liquid substance to spread and adhere to a solid food surface (Saguy & Meiron 2007). One gram of the tea sample was dropped from a height 15 mm onto the surface of 200 cm of distilled water contained in 250 cm^3 at room temperature. The wetting time was regarded as the time required for all the tea to become wetted and penetrate the surface of the still water (Chen & Chen 2024).

DETERMINATION OF NUTRITIONAL PROPERTIES

The moisture, ash and fiber content of the tea samples were determined by the method described by AOAC (2010). The method described by Krishnaiah et al. (2009) was used for vitamin C determination.

DETERMINATION OF PHYTOCHEMICAL CONTENT

Five grams of the sample was weighed into a 250ml beaker and 200ml of 20% acetic acid in ethanol was added and covered and allowed to stand for 4 hours at 25^{o}C. It was then filtered and the filtrate was concentrated using water-bath (Memmert) to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute NH_4OH solution. It was then filtered using a pre-weighed filter paper. The residue on the filter paper is the alkaloid and was dried in the precision oven at 80^{o}C, as recommended by Zhong et al. (2021). The alkaloid content was calculated and expressed as a percentage of the weight of the sample analyzed, thus:

$$\%Alkaloid\ content = \frac{weight\ of\ filter\ paper\ and\ precipitate - weight\ of\ filter\ paper}{weight\ of\ sample\ analyzed} \times 100$$

To determine flavonoid content, the method described by Zahra et al. (2024) was used.
To determine Saponin content, the method described by Zhong et al. (2021) was used.

MICROBIAL DETERMINATION

Before analysis, the working surface was cleaned and sterilized using alcohol (70%) (Surface sterilization). Also, petri dishes were sterilized by autoclaving at 121°C/15mins. Nutrient agar (NA) was used for total bacteria count. NA: 28g was dissolved in 1 liter distilled water. The NA was autoclaved at 121°C/15mins and kept in a hot bath till utilization. 1ml (0.1%) of samples were dissolved in 9ml of distilled water to obtain the dilution of 10^{-1} (solution). 1ml of the solution 1 was mixed with 9ml distilled water to give 10^{-2}. This process was repeated until a 10^{-6} dilution was obtained.

The Pour plate method was utilized. 1ml of appropriate dilution with respect to the media and about 15-20ml of media culture were added into the dilutions and allowed to coagulate. After coagulation, incubation was done according to the following media: Nutrient Agar: 37 °C 24 hours. Colony counting was done using a colony counter for Total Bacteria Count and recorded in colony forming units (cfu)/ml.

MICROBIAL ACTIVITY: Tea samples were introduced onto the petri dishes at the following concentrations: 0.25%, 0.5% and 1% for microbial activity, except for the control sample which had only rice (containing 150 cfu/ml of bacteria) without the tea samples. Before inoculation, the tea samples were boiled at 100 ^{0}c for 30 min to ensure they are no microbes on it. After inoculation, the samples were incubated at 30 ^{0}c for 24hours and then counted. Results were compared to that of the control in terms of the numbers of colony forming units.

SENSORY EVALUATION

The samples representing the various blends of Roselle, Cinnamon and Turmeric teas were evaluated for appearance, aroma, taste, texture, and general acceptability using the 9-point hedonic scale. The panelists consisted of 45 students from the department of food science at the Catholic University of Cameroon Bamenda. They were instructed on how to evaluate the samples.

STATISTICAL ANALYSIS

Data were imputed using Microsoft Excel and analyzed using SPSS version 21. Descriptive, inferential statistics and a sensory evaluation analysis was done. Mean and standard deviations were calculated while One-way ANOVA, post-hoc test was used to test for significant difference amongst the sample at p=0.05. The sample means were differentiated at significant level p=0.05.

RESULTS

The physical properties differed significantly from samples A to E (P<0.005), as shown in Table 1. The nutritional properties of samples A to E that were measured as shown in Table 2. The phytochemical content of samples A to E is shown in Table 3.

Table 1. Physical Properties of the herbal tea formulations

Formulations (C:R:T)	Bulk density (g/dm3)	pH	Dispersibility (%)	Wettability (min)
A 100C	$0.53^{a} \pm 0.01$	$6.71^{d} \pm 0.00$	$25^{a} \pm 0.00$	$9.15^{c} \pm 0.21$
B 70:20:100	$0.53^{a} \pm 0.01$	$3.82^{c} \pm 0.01$	$26^{ab} \pm 0.07$	$5.6^{a} \pm 0.57$
C 50:40:10	$0.60^{b} \pm 0.01$	$3.53^{b} \pm 0.00$	$28^{b} \pm 0.01$	$9.75^{c} \pm 0.35$
D 40:50:10	$0.91^{d} \pm 0.00$	$3.38^{a} \pm 0.01$	$28^{b} \pm 0.00$	$7.78^{b} \pm 0.31$
E 20:70:10	$0.70^{c} \pm 0.01$	$3.42^{a} \pm 0.00$	$28^{b} \pm 0.01$	$6.75^{a} \pm 0.35$

Data are ± of triplicate readings, means within columns with different superscripts were significantly different (p<0.05). C:R:T =Cinnamon: Roselle: Turmeric.

Table 2: Nutritional properties of the herbal tea formulations

Formulations (C:R:T)	Moisture (g/100g)	Ash (g/100g)	Fiber (g/100g)	Vitamin C (mg/100g)
A 100C	$10.1^{a}\pm0.14$	$1.62^{a}\pm0.02$	$0.97^{b}\pm0.01$	$13.2^{ab}\pm1.2$
B 70:20:100	$11.3^{a}\pm0.54$	$1.85^{bc}\pm0.06$	$0.96^{b}\pm0.04$	$8.8^{a}\pm2.2$
C 50:40:10	$11.3^{a}\pm0.54$	$1.92^{c}\pm0.14$	$0.79^{a}\pm0.01$	$17.6^{b}\pm1.0$
D 40:50:10	$11.4^{a}\pm0.57$	$2.10^{c}\pm0.14$	$0.99^{bc}\pm0.01$	$33^{c}\pm3.3$
E 20:70:10	$11.3^{a}\pm0.37$	$1.72^{b}\pm0.03$	$1.17^{c}\pm0.04$	$13.2^{ab}\pm0.91$

Data are ± of triplicate readings, means within columns with different superscripts were significantly different (p<0.05). C:R:T =Cinnamon: Roselle: Turmeric

Table 3: Phytochemical content of the herbal tea formulations (mg/100g)

Formulations (C:R:T)	Alkaloids	Flavonoids	Saponins
A 100C	$3.29^{a}\pm0.00$	$7.93^{d}\pm0.05$	$1.85^{d}\pm0.07$
B 70:20:100	$3.63^{a}\pm0.04$	$7.83^{d}\pm0.04$	$0.91^{b}\pm0.01$
C 50:40:10	$2.67^{a}\pm0.47$	$6.62^{b}\pm0.01$	$0.53^{a}\pm0.04$
D 40:50:10	$6.11^{c}\pm0.16$	$7.63^{c}\pm0.04$	$2.68^{d}\pm0.25$
E 20:70:10	$5.34^{b}\pm0.01$	$5.87^{a}\pm0.04$	$1.35^{c}\pm0.07$

Data are ± of triplicate readings, means within columns with different superscripts were significantly different (p<0.05). C:R:T =Cinnamon: Roselle: Turmeric

MICROBIAL ACTIVITY OF THE HERBAL TEA FORMULATIONS

There were no differences in microbial counts/activity amongst all the tea samples at 10^{-5} and 10^{-6} dilution factor as shown in Table 4.

Table 4: Microbial count of the herbal tea formulations (cfu/g) ($10^{-5}/10^{-6}$ dilution)

Formulations (C:R:T)	Samples	10^{-5} dilution	10^{-6} dilution
A 100C	A	$5^{a}\pm1$	$3^{a}\pm1$
B 70:20:100	B	$11^{a}\pm3$	$4^{a}\pm2$
C 50:40:10	C	$8^{a}\pm2$	$2^{a}\pm1$
D 40:50:10	D	$3^{a}\pm2$	$5^{a}\pm2$
E 20:70:10	E	$6^{a}\pm2$	$5^{a}\pm3$

Data are ± of triplicate readings, means within columns with different superscripts were significantly different (p<0.05). C:R:T =Cinnamon: Roselle: Turmeric

Sensory attributes of the herbal tea formulations

Sensory attribute data were recorded and analyzed as to appearance, aroma, taste, texture and general acceptability, as shown in Table 5. Sensory attributes were significantly different across the various samples (p<0.05).

Table 5. Sensory attributes of the herbal tea formulations

Formulations (C:R:T)	Appearance	Aroma	Taste	Texture	General acceptability
A 100C	$7.17^{b}\pm1.4$	$6.81^{a}\pm1.5$	$5.90^{a}\pm1.2$	$6.63^{a}\pm1.7$	$7.41^{a}\pm1.2$
B 70:20:100	$6.24^{a}\pm1.4$	$6.02^{a}\pm1.8$	$6.17^{ab}\pm1.8$	$6.81^{a}\pm1.4$	$6.95^{a}\pm1.4$
C 50:40:10	$7.19^{b}\pm1.7$	$6.84^{a}\pm1.3$	$6.73^{b}\pm1.7$	$6.91^{a}\pm2.0$	$7.29^{a}\pm1.7$
D 40:50:10	$7.21^{b}\pm1.7$	$6.65^{a}\pm1.6$	$6.66^{b}\pm1.7$	$6.93^{a}\pm1.4$	$7.44^{a}\pm0.9$
E 20:70:10	$7.38^{b}\pm1.7$	$6.67^{a}\pm1.7$	$7.15^{b}\pm1.6$	$7.19^{a}\pm1.6$	$7.54^{a}\pm1.5$

Data are ± of triplicate readings, means within columns with different superscripts were significantly different (p<0.05). C:R:T =Cinnamon: Roselle: Turmeric

DISCUSSION

PHYSICAL PROPERTIES

The presence of Roselle and turmeric in the samples caused an increase in bulk density compared to the samples consisting mainly of cinnamon, similar to the findings of (Suseno et al. 2022). pH values varied among the samples. The increased dispersibility in samples C, D, and E can be attributed to the addition of roselle and turmeric, similar to results from Etheridge et al. (2020). Roselle's high pectin content is well recognized to enhance the dispersibility of herbal tea.

Samples with a high proportion of Roselle and low proportion of cinnamon exhibited decreased wettability compared to samples with a high proportion of cinnamon and a low proportion of Roselle. The low wettability properties of Roselle can be attributed to its chemical composition, specifically the presence of polysaccharides (Suseno et al. 2022) and bioactive compounds such as phenolic acids, that can alter the surface tension of liquids and enhance its spreading abilities (Suseno et al. 2022).

NUTRITIONAL PROPERTIES

Cinnamon typically contains around 10% moisture content, while Roselle has a lower moisture content of about 7-8% (Djaeni et al., 2018). As the proportion of cinnamon increased in the samples, the moisture content also increased. However, the presence of Roselle in the samples did not show a significant impact on the moisture content levels. According to Djaeni et al. (2018) high levels of moisture content in food product samples may result in quality deterioration, while lower moisture content indicates that the sample will have a longer shelf life (Juhari et al., 2021).

The ash content is a measure of the minerals found in a food material (Edo et al, 2023). Sample D recorded the highest mean score for ash content, which can be attributed to Roselle's high iron, calcium, potassium and magnesium content. The calcium content of Roselle is 5 times higher than that found in milk and the iron content of Roselle is 7 times higher than that found in apples (Edo et al. 2023). Mineral elements in turmeric also contribute to the samples' high ash content (Edo et al. 2023).

Roselle is rich in dietary fiber according to Etheridge et al. (2023). This fiber provides bulk in the diet, promoting a feeling of fullness which helps prevent overeating and aids in weight management. Additionally, the high fiber content in Roselle helps to regulate digestion and prevent constipation Edo et al. (2023). The fiber content was found highest in Sample E, which had the highest proportion of Roselle (70%). A relatively high vitamin C content was recorded in sample D, possibly due to the fact that Roselle and cinnamon are good sources of vitamin C (Djaeni et al., 2018).

PHYTOCHEMICAL CONTENT

The high alkaloid content in sample D, 6.11mg/100g, is indicative of pharmacological potential such as anti-cancer and anti-hyperglycemic properties by regulating blood sugar levels (Edo et al., 2023).

The flavonoid content increased in samples with more cinnamon, with bioactive compounds like polyphenols including flavonoids (gossypin, quercetin, hesperidin, hibifolin and hypolaetin) and tannins which are present in cinnamon bark. They have anti-obesogenic and anti-inflammatory effects, promoting glucose intake and insulin sensitivity, as well asanti-oxidant properties for helping to prevent cardiovascular diseases (Chopra et al. 2023).

The saponin content in food is an indication that it has the potential to have beneficial effects on health, such as lower cholesterol levels, improve immune function, and it has anti-inflammatory properties. It also has anti-carcinogenic properties, anti-viral, antifungal, and antibacterial activities (Chopra et al. 2023). Sample D recorded the highest value of saponin.

MICROBIAL COUNT

Results suggested the presence of anti-microbial compounds in these herbal teas. Generally, as the concentration of phytochemicals in the samples increased, microbial growth decreased. All samples were generally safe for consumption.

SENSORY EVALUATION

Consumer appetite for food is stimulated by its appearance/color. The three most preferred samples (E, D and C) had a higher proportion of Roselle (70%, 50% and 40%) respectively. Similarly, dark-red zobo drinks (Hibiscus Sabdariffa drink) was rated higher than the lighter colored ones in Cameroon (folere) (Ezekiel et al. 2016). Roselle infusion has been described as a red, transparent liquid which many people find attractive (Edo et al., 2023).

Samples C and A which had high proportions of cinnamon, resulted in a more pronounced and desirable aroma, presumably due to the presence of its volatile compounds such as cinnamaldehyde (Chopra et al., 2023). However, samples E and C which had higher proportions of Roselle than cinnamon, were preferable to sample B which contained 70% cinnamon. A possible explanation is that the high roselle content in sample E and Chad produced a good aroma combination which was appreciated by the sensory panelist, thereby resulting in its high aroma ratings.

The three most preferred samples for taste were sample E, C and D, which all had a high proportion of Roselle. Roselle is known to have a tangy and tart taste, often compared to cranberries. The least preferred was sample A.

Texture refers to those qualities of a food that can be felt with the fingers, tongue, palate or teeth. Sample E was the most preferred in terms of texture followed by sample D, C, B and A. Samples with low proportions of Roselle were least preferred in terms of texture. The samples which had high proportions of Roselle had a smooth and slightly viscous texture that creates a rich and full-bodied mouth feel that many people find enjoyable (Edo et al., 2023).

Sample E, the most preferred in appearance, taste and texture, had the highest overall mean score in general acceptability. Sample B was the least preferred in general acceptability.

CONCLUSION

Among the herbal tea powders we tested, Sample D, composed of 40% cinnamon, 50% roselle, and 10% turmeric, exhibited the highest levels of alkaloids, flavonoids, and saponins as well as elevated levels of ash, fiber, and Vitamin C. Regarding, Sample D received the second highest overall sensory evaluation score. Thus we judged Sample D as the overall best sample.

AUTHOR CONTRIBUTIONS

MKN, FAA, DM: conceptualization and methodology. MKN: investigation, data collection. DM: Formal software analysis. FAA: Prepared the manuscript with input from MKN and DM. FAA and DM: Supervised the study. All authors have read and approved the final version of the paper and its submission.

CONFLICT OF INTEREST

The authors declare that they have no other potential conflicts of interest.

DATA AVAILABILTY

The data will be made available upon request

CONSENT FOR PUBLICATION

All authors have read and agreed to the submitted version of the manuscript.

ETHICAL CONSIDERATION

Administrative clearance was sought from the Catholic University o Cameroon where the study was carried out. Panellists were required to sign a consent form before taking part in tasting the tea samples.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN SCIENTIFIC WRITING

The authors declared that they used AI tool ChatGPT to generate a draft of the Chicago- Author style of referencing for the reference list.

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