



Quality and sensory attributes of composite herbal tea from *Parquetina Nigrescens* (Parquetina) and *Cymbopogon Citratus* (Lemongrass)

Victoria Auhoiza Joshua^{1,4} · Mayowa Saheed Sanusi² · Olufunmilola Adunni Abiodun¹ · Bukola Idowu Kayode¹ · Stephen Orobola Olabanji³ · Ojochenemi Rebecca Egwumah¹ · Rowland Monday-Ojo Kayode¹ 

Received: 21 August 2022 / Accepted: 19 January 2023

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2023

Abstract

Herbal teas are functional foods that interest consumers as they contain bioactive compounds known to promote health. As such, five different formulations of Parquetina and Lemongrass (100:0%, 87.5:12.5%, 75:25%, 62.5:37.5% and 50:50%) were used for the development of composite herbal teas which were evaluated for their phytochemical and mineral compositions, antioxidant capacities, microbiological quality and sensory attributes. The phytochemicals present in the composite herbal teas included phenols that ranged from 0.36 to 0.90 mgGAE/100ml, flavonoids (0.25 to 0.58 mgQE/100ml), alkaloids (0.12 to 0.79 mg/100 ml), saponins (0.04 to 0.14 mg/100ml), cardiac glycosides (0.01 to 0.1 mgDT/100ml), tannins (0.03 to 0.05 mgTAE/100ml) and terpenoids (0.04 to 0.25 mg/100ml). Potassium was the mineral with the highest concentration and it ranged from 15.06 to 21.19 mg/100ml in the tea samples. The composite herbal teas showed antioxidant capacities that ranged from 17.77 to 40.96%. The total bacterial count of the composite herbal tea ranged from 8.05×10^4 to 8.95×10^4 cfu/g, total fungal count (2.55×10^4 to 3.05×10^4 cfu/g) and total coliform count (5.50×10^2 to 7.5×10^2 cfu/g). Sensory evaluation showed that the most preferred sample was P₅₀L₅₀ (50% parquetina and 50% lemongrass). Conclusively, parquetina and lemongrass could be utilized in the production of a composite herbal tea with good quality and sensory attributes.

Keywords Functional foods · Herbal tea · Infusions · Lemongrass · Parquetina

Introduction

Consumers' attentions are beginning to shift in the favour of foods that do not only supply nutrients and energy, but also serve specific health beneficial functions due to the presence of bioactive components with health promoting properties in them. These foods are known as "functional foods" and the bioactive components are known to improve certain physiological responses and/or reduce the risks of diseases and optimize health [1]. The quality attributes of tea are dependent on the bioactive compounds e.g. phytochemicals inherent in the raw material. These compounds are generally responsible for the sensory, nutritional and health benefits derived from tea consumption. Herbal teas are considered functional foods owing to the presence of bioactive compounds in them. Herbal tea is tea made from any other plant apart from the tea plant *Camellia sinensis* [2].

✉ Rowland Monday-Ojo Kayode
rowland@unilorin.edu.ng

¹ Department of Home Economics and Food Science, Faculty of Agriculture, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria

² Department of Food Engineering, Faculty of Engineering, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria

³ Department of Microbiology, Faculty of Life Sciences, University of Ilorin, P.M.B. 1515, Ilorin, Kwara State, Nigeria

⁴ Department of Science Laboratory and Technology, School of Applied Sciences, Kogi State Polytechnic Lokoja, P.M.B. 1101, Lokoja, Kogi State, Nigeria

Parquetina (*Parquetina nigrescens*) is a perennial climbing plant of the Asclepiadaceae family, native to equatorial West Africa [3]. Parquetina is largely distributed in Africa (particularly in Senegal and Nigeria) and it is mainly found during the rainy season (April – October). Parquetina is widely used in ethnomedicine. A leaf decoction or infusion is used to treat constipation, intestinal worms, diabetes, stomach ulcers, jaundice, fatigue, anaemia, epilepsy, venereal diseases, convulsions, as part of ingredients used to treat insanity and as a laxative and to ease childbirth [4, 5]. It is a major constituent of the Jubi formula – commercial herbal preparation in Nigeria for the treatment of anaemia. Parquetina is reported to contain phenols, alkaloids, flavonoids, saponins, tannins, cardiac glycosides and terpenoids, minerals like iron, copper, magnesium, manganese and zinc, and vitamins such as tocopherols, folic acid, cobalamin and ascorbic acid which all account for its medicinal properties [6, 7].

Lemongrass (*Cymbopogon citratus*) is a perennial tall grass in the Poaceae family, with a strong aromatic lemon-like flavour. It originated from India but is widely grown across the globe, mainly in the tropical and savannah regions. Lemongrass contains flavonoids, phenolic acids and terpenoids, alkaloids, tannins, vitamins thiamine, pantothenic acid and pyridoxine, and minerals like potassium, zinc, calcium, iron, magnesium, manganese and copper which foster its use in medicine and in the food industry. Lemongrass is rich in aromatic essential oils which have high levels of volatile compounds like citral and myrcene [8, 9]. Lemongrass is commonly employed in traditional medicine for its restorative, digestive, effective against colds, analgesic, anti-hermetic, anti-thermic, anti-inflammatory of urinary ducts, diuretic, antispasmodic, diaphoretic and anti-allergic properties. Infusions from the fresh or dried leaves are commonly used in many countries across the globe. In Nigeria, the leaves are boiled with guava leaves to give relief from cough and fevers; in the Philippines, the leaves are crushed and applied on the forehead to relieve headaches; in Egypt, an infusion is taken orally as a diuretic and renal anti-spasmodic; the Indonesians and Malaysians use it to stimulate blood flow in the pelvic area and uterus. Lemongrass is also widely used in the treatment of stomach infections, nausea, stomach aches, constipation, nervous conditions and inflammations, and to prevent ulcers, stimulate digestion and excretion [8, 10].

Previous research have shown evidence that the combination of different herbs exhibit synergism in nutritional composition, sensory attributes and health-promoting properties, thus, improving consumer acceptance of such products [11]. Therefore, this study investigated the use of Parquetina and Lemongrass for the production of a composite herbal tea with good quality and sensory attributes.

Materials and methods

Plant materials

The leaves of Parquetina and Lemongrass were collected within Ilorin Metropolis. They were identified and authenticated at the Plant Herbarium Unit of the Department of Plant Biology, University of Ilorin, and given voucher numbers UILH/002/2019/980 and UILH/003/2019/1284, respectively. They were sorted and cleaned for further processing.

Tea production

The procedure described by [12] was used for the production of the composite herbal tea. Fresh leaves were cleaned under running tap water and steam-blached at 100⁰ C for five minutes and then dried in a cabinet dryer at 40⁰ C. The dried leaves were milled using an electric Binatone blender (Model BLG 600s, China) and passed through a 40 mesh sieve to obtain fine powder of 0.425 mm. This procedure was followed for each plant after which the milled plants were mixed in different proportions to obtain five formulations of Parquetina and Lemongrass at 100:0%, 87.5:12.5%, 75:25%, 62.5:37.5% and 50:50% of tea powder. The formulations were obtained using Design Expert (Version 12, Stat-Ease Inc., Minneapolis, USA) Package. The tea powder was packed in 55×75 mm tea bags (1 g/tea bag) and stored in opaque glass bottles to protect the phenolic content from degradative reactions and maintain their antioxidant capacities.

Preparation of tea infusions

The modified method of [12] was followed for the preparation of the infusions. Infusions were made by pouring 100ml of boiling water over one teabag (i.e. 1 g) of each sample formulation and allowed to infuse for five minutes.

Physicochemical analyses

Moisture content and water soluble extracts of the tea powder were determined following the methods adopted by [13]. Infusion rate was calculated by dividing the weight of water soluble extracts by the infusion time. The pH and colour parameters of infusions were determined using digital pH meter (VBESTLIFE, series EZ-9903) and Chroma meter (A60-1014-593, Hunter Associates, USA.), respectively. Turbidity was calculated as 100 – T% in a method described by [14].

Phytochemical analyses

Infusions were analysed for phytochemical composition. Phenols and tannins were determined by the Folin-Ciocalteu's reagent method and concentrations are represented as milligramme of gallic acid equivalent (mgGAE/100ml) and milligramme of tannic acid equivalent (mgTAE/100ml), respectively per 100ml of infusion. Flavonoids were determined using the aluminium chloride method, concentrations are represented as milligrammes of Quercetin equivalent per 100ml of infusion (mgQE/100ml) as adopted by [13]. The methods of [15] were used for the determination of alkaloids, saponins and terpenoids. Cardiac glycosides were determined according to the method reported by [16] and concentrations are expressed as milligrammes of Digitoxin equivalent per 100ml of infusion (mgDTE/100ml).

Mineral analyses

Infusions were wet digested using 10ml of freshly prepared Aqua-Regia acid mixture (1:3 of 65% HNO₃ and 37% HCL) and analysed for Calcium, Magnesium, Potassium, Iron, Zinc, Copper and Sodium using the Atomic Absorption Spectrophotometer (BUCK Scientific ACCUSYS 211) at 422.7 nm, 285.2 nm, 766.5 nm, 248.3 nm, 213.9 nm, 324.7 nm and 589 nm, respectively in a method reported by [17].

Antioxidant capacity

The modified method of [18] was used to determine the antioxidant capacity of the infusions by measuring their scavenging effect on 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) radical. 50 µl of samples was added to 200 µl of a solution of 0.135mM DPPH in methanol. The mixture was left in the dark at room temperature for 30 min after which absorbance was read at 517 nm. Methanol solution of DPPH without the sample was used as control and Ascorbic acid in distilled water was used as standard. The antioxidant capacity of the samples was calculated as using the formula below.

$$\text{Antioxidant capacity (\%)} = \frac{Abs_{DPPH} - Abs_{sample}}{Abs_{DPPH}} \times 100$$

Where Abs_{DPPH} is the absorbance of the methanol solution of the DPPH radical, and Abs_{sample} is the absorbance of the sample + DPPH radical.

Microbiological assessment

The microbiological status of the composite tea powder was assessed following the modified method reported by [19] and used as a measure to indicate that the composite herbal

tea was hygienically prepared and are therefore, safe for consumption.

Sample preparation and plating were done under aseptic conditions in a laminar flow cabinet. The media were prepared according to manufacturers' specifications and sterilized at 121°C, 15psi for 15 min. Two ten-fold serial dilutions of each sample were prepared and samples were assessed for total bacteria, fungi and coliforms using the pour plate method. Bacteria were enumerated on nutrient agar at 37⁰ C for 24 h, fungi were enumerated on potato dextrose agar (containing streptomycin at a concentration of 30 µg/ml) at 28⁰ C for 72 h and coliforms were enumerated on eosin methylene blue agar at 44⁰ C for 24 h. Eosin methylene blue agar is a selective and differential medium able to evidence the presence of *Escherichia coli* through the growth of a typical metallic green sheen due to the meta-chromatic properties of the dyes.

Sensory evaluation

The modified method of [8], was adopted. Thirty (30) semi-trained food evaluators were recruited from the Department of Home Economics and Food Science, University of Ilorin, Ilorin, Nigeria. Panellists were chosen based on their willingness, availability and familiarity with herbal teas and were given no prior information regarding the constituents of the sample formulations. Infusions were assigned three digit codes and 30ml of each was served at 60⁰ C in transparent disposable cups to the panellists, in no particular order. Panellists were provided with warm water to rinse their mouths before and after evaluation of each sample. The sensory attributes assessed included appearance, flavour, astringency and overall acceptability and these were scored using a 9-point hedonic scale with '1' meaning 'dislike extremely' and '9' meaning 'like extremely'. Panellists were provided with questionnaires to record their observations.

Statistical analysis

Results are expressed as mean of three replicates ($n = 3$) ± standard deviation (SD) and analysed using One-way ANOVA. Significant differences between means were assessed by the Duncan Post Hoc test, and $P \leq 0.05$ was considered as statistically significant. Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) software, version 20 (SPSS Inc., Chicago, IL, USA). A Pearson correlation test was done to determine the correlation between the phytochemicals and antioxidant capacity of the composite herbal tea.

Table 1 Physico-chemical properties of parquetina and lemongrass composite herbal tea

Samples	Water soluble extract (%)	Moisture content (%)	pH	IR (mg/min)	Turbidity (%)	L^*	Colour a^*	b^*
P ₁₀₀ L ₀ (control)	58.37±0.47 ^c	5.73±0.01	7.37±0.00 ^a	116.74±0.47 ^c	41.20±0.01 ^a	43.57±0.08 ^c	3.23±0.04 ^a	4.80±0.00 ^c
P _{87.5} L _{12.5}	62.39±0.03 ^d	5.76±0.04	7.31±0.07 ^{ab}	124.78±0.03 ^d	37.60±0.05 ^b	44.55±0.21 ^d	3.19±0.03 ^{ab}	5.29±0.06 ^d
P ₇₅ L ₂₅	65.66±0.04 ^c	5.75±0.07	7.29±0.25 ^{ab}	131.32±0.04 ^c	36.79±0.11 ^b	46.46±0.07 ^c	3.16±0.01 ^b	6.99±0.11 ^c
P _{62.5} L _{37.5}	69.65±0.42 ^b	5.73±0.04	7.19±0.01 ^{bc}	139.30±0.42 ^b	34.00±0.73 ^c	48.95±0.36 ^b	2.68±0.01 ^c	10.38±0.23 ^b
P ₅₀ L ₅₀	72.37±0.35 ^a	5.73±0.02	7.08±0.11 ^c	144.74±0.35 ^a	31.11±0.00 ^d	51.56±0.37 ^a	2.63±0.03 ^c	12.97±0.12 ^a

Values are expressed as mean ($n=3$)±S.D. Means with the different superscripts along a column are significantly ($P\leq 0.05$) different. IR = infusion rate; P₁₀₀L₀ (control) = Parquetina only; P_{87.5}L_{12.5} = 87.5% Parquetina and 12.5% Lemongrass; P₇₅L₂₅ = 75% Parquetina and 25% Lemongrass; P_{62.5}L_{37.5} = 62.5% Parquetina and 37.5% Lemongrass; P₅₀L₅₀ = 50% Parquetina and 50% Lemongrass.

Results and discussion

Physicochemical properties of composite herbal tea from parquetina and lemongrass

The physicochemical properties of the samples as represented in Table 1 show that water-soluble extracts in the samples ranged from 58.37±0.47 to 72.37±0.35% with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively and the infusion rates ranged from 116.74±0.47 to 144.74±0.35 mg/min with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively. All samples were significantly ($P\leq 0.05$) different from one another. Water soluble extracts represent the portion of the tea that is soluble in water. Often expressed as a percentage, it is indicative of the quality of the tea. In this study, all samples meet the basic international requirement which states that water-soluble extracts in teas should be greater than or equal to 32% [20]. The infusion rate is the amount of extracts per time. It is often used as a function of solubility. The findings of this study show that the composite herbal tea samples have high infusion rates, which can be used as a pointer to high solubility. In a composite herbal tea, the herb with more water-soluble extracts will have more influence on the character of the infusion [8]. This may be why the water-soluble extracts and infusion rates of the samples increased with increasing amounts of Lemongrass in the formulation.

The moisture contents of the samples ranged from 5.73±0.01 to 5.76±0.04% with samples P₁₀₀L₀ and P_{87.5}L_{12.5} having the lowest and highest values, respectively. No significant difference ($P\geq 0.05$) was recorded among the samples. Moisture content being an important quality parameter is used as an index for good storage as the proliferation of microorganisms (especially moulds) is known to be enhanced by high moisture in foods. For this reason, tea intended for long-term storage should have moisture content that ranged between 2.5 and 6.5% [21]. The result from this study reflects conformity to this specification.

pH of the samples ranged from 7.08 to 7.37, with samples P₅₀L₅₀ and P₁₀₀L₀ having the lowest and highest values,

respectively. Only samples P₁₀₀L₀ and P₅₀L₅₀ were significantly different ($P\leq 0.05$). The pH of all the samples depicts that the composite herbal tea samples are alkaline. This finding is in agreement with findings of [22], who stated that the pH of most herbal teas are either near alkaline or alkaline. This implies that the samples have no erosive and damaging potentials to teeth as erosion on enamel surfaces and decay of teeth are usually attributed to the consumption of highly acidic beverages. More so, they are less likely to cause acid reflux in the stomach [23].

Colour determination shows that the L^* (Lightness) values of the samples varied between 43.57±0.09 and 51.56±0.37, lowest and highest values were recorded for samples P₁₀₀L₀ and P₅₀L₅₀, respectively. a^* (-ve = green, +ve = red) values ranged from 2.63±0.03 to 3.23±0.04 with the lowest and highest values recorded for samples P₅₀L₅₀ and P₁₀₀L₀, respectively. The values were positive indicating that the a^* values tended towards the red axis. b^* (-ve = blue, +ve = yellow) values ranged from 4.8±0.00 to 12.97±0.12 with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively. The b^* values were positive indicating that values tended towards the yellow axis. L^* and b^* values significantly ($P\leq 0.05$) increased with increasing amounts of Lemongrass in the sample formulations. On the other hand, a^* values significantly ($P\leq 0.05$) decreased with increasing amounts of Lemongrass in the sample formulations. Colour is an important organoleptic characteristic of tea as it influences the acceptability of the product, and the colour of tea is majorly dependent on the flavonoids in the tea [24]. Correlation study shows strong positive relationship ($r=0.983^{**}$) between the flavonoid concentrations and L^* values and between the flavonoid concentrations and b^* values ($r=0.964^{**}$) of the tea samples. This also corresponds to the increasing amounts of Lemongrass in the sample formulations. This may mean that the flavonoids in Lemongrass are of the type that impact lightness and yellowness. Correlation study between the flavonoid concentrations and the a^* values of the tea samples show a strong negative relationship ($r=-0.997^{**}$). This corresponds to the decreasing amount of Parquetina in the sample formulations, probably indicating that the flavonoids in Parquetina are of the type

that impact redness. From the results of this study, it can be inferred that the colour of the composite herbal tea samples were reddish-yellow (popularly known as “sunset yellow”). This is in contrast with the report of [25] which stated that the desired colour of green tea is green or yellowish-green. Notwithstanding, this is dependent on the plant material employed.

Turbidity values ranged from 31.11 ± 0.00 to $41.20 \pm 0.02\%$, with samples $P_{50}L_{50}$ and $P_{100}L_0$ having the lowest and highest values, respectively. All samples are significantly ($P \leq 0.05$) different from the control sample $P_{100}L_0$. Turbidity is the optical property that describes cloudiness in a fluid, characterized by the scattering of light caused by solids invisible to the naked eye [14]. Turbidity of the composite herbal tea was fairly high, nevertheless, this did not cause a decrease in the appearance score, contrary to the report of [14] who mentioned that high turbidity has a negative influence on the appearances of beverages, thus, making them less appealing.

Phytochemical composition

Phenol content of the samples ranged from 0.36 ± 0.02 to $0.9 \pm 0.01 \text{ mgGAE/100ml}$ with sample $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest values, respectively; all the samples are significantly ($P \leq 0.05$) different from one another except for samples $P_{100}L_0$ and $P_{87.5}L_{12.5}$. [26] reported lower values for *Hibiscus sabdariffa*, *Ocimum sanctum*, and *Mentha spicata* herbal teas. However, [27] reported higher values for herbal tea made from *Chromolaena odorata*. Phenols are known for their antioxidant, anti-inflammatory, anti-allergic, anti-diabetic, anti-carcinogenic, antihypertensive, anti-tumour and antimicrobial properties [28].

The flavonoid content of the samples ranged from 0.25 ± 0.06 to $0.58 \pm 0.00 \text{ mgQE/100ml}$, with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from one another except samples $P_{100}L_0$ and $P_{87.5}L_{12.5}$. [27] reported higher values for herbal tea made from *Chromolaena odorata*, while [26] reported lower values for *Hibiscus sabdariffa*, *Ocimum sanctum*, and *Mentha spicata* herbal teas. Flavonoids have been reported to have properties that help inhibit oxidation, allergies, inflammations, cancer, diarrhoea and microorganisms [28].

Alkaloid content varied from 0.12 ± 0.01 to $0.79 \pm 0.13 \text{ mg/100ml}$, with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different except samples $P_{100}L_0$ and $P_{87.5}L_{12.5}$. Similar results were reported by [27] for herbal tea made from *Chromolaena odorata*. Alkaloids act as stimulants and can be used as analgesic to relieve pain and relax

muscles. Furthermore, alkaloids have anti-malarial, anti-inflammatory, anti-tumour, antioxidant, anti-diarrhetic, anti-arrhythmic, anti-mutagenic and anti-ulcer activities [28].

Saponins ranged from 0.04 ± 0.01 to $0.14 \pm 0.01 \text{ mg/100ml}$, with samples $P_{50}L_{50}$ and $P_{100}L_0$ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from one another. This finding disagrees with the finding of [27] who reported higher values for the saponin content of *Chromolaena odorata* herbal tea. Saponins have been reported to enhance the immune system by improving immune response to antigens; lower cholesterol and glucose levels by inhibiting cholesterol absorption from the small intestine; have anti-tumour, anti-hepatic, antioxidant properties [29].

Cardiac glycosides ranged from 0.01 ± 0.0 to $0.10 \pm 0.04 \text{ mgDTE/100ml}$, with samples $P_{50}L_{50}$ and $P_{100}L_0$ having the lowest and highest values, respectively; samples are significantly ($P \leq 0.05$) different. Herbal teas formulated from *Magnifera indica*, *Moringa oleifera* and *Zingiber officinale* were reported [30] to contain much higher amounts of cardiac glycosides than the amounts reported for the herbal teas in this study. Cardiac glycosides are known for increasing the force of cardiac muscle contraction and increasing heart rate, making them useful in the treatment of congestive heart failure and cardiac arrhythmia. Cardiac glycosides have strong potency and must be only be used at low levels as high levels can cause premature ventricular contraction and be fatal [31]. Daily oral intake of less than 1 mg is safe [32]. This implies that the cardiac glycoside content of the herbal teas in this study poses no health risks.

Tannins ranged from 0.03 ± 0.07 to $0.05 \text{ mgTAE/100ml} \pm 0.03$, with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest values respectively. Previous researchers [26, 27] have reported higher levels of tannins in herbal teas formulated from *Phlogacanthus thyrsiformis* and *Chromolaena odorata*, respectively. Tannins have been reported to have anti-diarrheal, anti-carcinogenic, anti-tumour, anti-septic, anti-mutagenic, anti-microbial, anti-hypertensive, anti-diabetic and anti-inflammatory agents [33].

Terpenoids ranged from 0.04 ± 0.04 to $0.25 \pm 0.25 \text{ mg/100ml}$, with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different. This finding disagrees with the finding of [30] who reported much higher values for the terpenoid content of herbal tea formulated from *Magnifera indica*, *Moringa oleifera* and *Zingiber officinale*. Terpenoids have anti-carcinogenic, anti-ulcer, anti-inflammatory, anti-diabetic, analgesic, and anti-microbial properties. In addition, they have anxiety-reducing effects which make them potent in lowering anxiety and increasing the feelings of calm and relaxation [34].

Table 2 Phytochemical composition of parquetina and lemongrass composite herbal tea

Phytochemicals	P ₁₀₀ L ₀	P _{87.5} L _{12.5}	P ₇₅ L ₂₅	P _{62.5} L _{37.5}	P ₅₀ L ₅₀
Phenols (mgGAE/100ml)	0.36 ± 0.02 ^c	0.42 ± 0.01 ^d	0.47 ± 0.05 ^c	0.49 ± 0.00 ^b	0.9 ± 0.01 ^a
Flavonoids (mgQE/100ml)	0.25 ± 0.06 ^d	0.25 ± 0.03 ^d	0.26 ± 0.02 ^c	0.44 ± 0.08 ^b	0.58 ± 0.00 ^a
Alkaloids (mg/100ml)	0.12 ± 0.01 ^d	0.14 ± 0.01 ^d	0.42 ± 0.00 ^c	0.68 ± 0.13 ^b	0.79 ± 0.13 ^a
Saponins (mg/100ml)	0.14 ± 0.01 ^a	0.09 ± 0.13 ^b	0.06 ± 0.18 ^c	0.05 ± 0.14 ^d	0.04 ± 0.01 ^e
Cardiac glycosides (mgDTE/100ml)	0.10 ± 0.04 ^a	0.08 ± 0.04 ^b	0.07 ± 0.02 ^c	0.04 ± 0.04 ^d	0.01 ± 0.00 ^e
Tannins (mgTAE/100ml)	0.03 ± 0.07 ^c	0.03 ± 0.00 ^c	0.04 ± 0.07 ^b	0.04 ± 0.06 ^b	0.05 ± 0.03 ^a
Terpenoids (mg/100ml)	0.04 ± 0.04 ^c	0.07 ± 0.08 ^d	0.9 ± 0.02 ^c	0.14 ± 0.03 ^b	0.25 ± 0.03 ^a

Values are expressed as mean ($n = 3$) ± S.D. Means with the different superscripts along a column are significantly ($P \leq 0.05$) different. mgGAE/100ml = milligram of gallic acid equivalent per 100ml infusion; mgQE/100ml = milligramme of Quercetin equivalent per 100ml infusion; mgTAE/100ml = milligram of tannic acid equivalent per 100ml infusion; mgDTE/100ml = milligram of digitoxin equivalent per 100ml infusion. P₁₀₀L₀ (control) = Parquetina only; P_{87.5}L_{12.5} = 87.5% Parquetina and 12.5% Lemongrass; P₇₅L₂₅ = 75% Parquetina and 25% Lemongrass; P_{62.5}L_{37.5} = 62.5% Parquetina and 37.5% Lemongrass; P₅₀L₅₀ = 50% Parquetina and 50% Lemongrass.

Overall, results showed that phenols were the most abundant phytochemical in the composite herbal tea samples. Several researchers like [26, 27, 35] have reported similar findings. The phenol, flavonoid, alkaloid, tannin and terpenoid contents of the composite herbal tea samples as shown in Table 2, significantly ($P \leq 0.05$) increased with increasing amounts of Lemongrass in the sample formulation, this may be because Lemongrass contributed more of these phytochemicals in the respective samples. This could be related to the higher amounts of water-soluble extracts (refer to Table 1) in formulations with higher amounts of Lemongrass. [8] mentioned that in a composite herbal tea, the herb with more water-soluble extracts will have more influence on the character of the infusion. Contrastingly, saponins and cardiac glycosides significantly reduced ($P \leq 0.05$) with decreasing amounts of Parquetina in the sample formulation, indicating that Parquetina contributed more of these phytochemicals in the respective samples.

Mineral content

Minerals are inorganic elements required by humans for proper functioning. They cannot be synthesized in the human body; hence, they must be obtained through food. From Table 3, it can be inferred that the minerals in the composite herbal tea samples included calcium, magnesium, potassium, zinc, iron, copper and sodium. Similar findings were reported by [36] for Parquetina, and by [37] for Lemongrass. Calcium levels in the tea infusions ranged from 4.63 ± 1.20 to 6.34 ± 0.11 mg/100ml, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest, respectively. All samples are significantly ($P \leq 0.05$) different from the control sample P₁₀₀L₀. Similar values were reported by [38, 39] for commercial herbal teas of varying formulations in Poland and North Ossetia, respectively. Calcium is an important mineral needed for the development and metabolism of bones and teeth. It is also required for the proper

functioning of nerves and muscles, blood clotting and regulation of fluid balance within cells [40].

Magnesium levels varied between 3.30 ± 0.14 and 4.70 ± 0.43 mg/100ml, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively; samples are significantly ($P \leq 0.05$) different from control sample P₁₀₀L₀, with the exception of sample P_{87.5}L_{12.5}. Values reported in this study fall within the range reported by [39] for commercial herbal teas of varying formulations in North Ossetia, however, [38] reported lower values for commercial herbal teas of varying formulations in Poland. Magnesium is necessary for the activation of ATP and ATPase pumps needed in electrolyte homeostasis. It is also needed for carbohydrate, protein and fat metabolism; energy transfer, storage and usage [40].

Potassium levels ranged from 15.06 ± 0.16 to 21.19 ± 0.36 mg/100ml, with samples P₅₀L₅₀ and P₁₀₀L₀ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from the control sample P₁₀₀L₀. In contrast to the finding of this study, [39] reported higher amounts of potassium in commercial herbal teas of varying formulations in North Ossetia. Potassium is needed primarily for the regulation of osmotic pressure, nerve function, skeletal and smooth muscle contraction and control [40].

Zinc levels ranged between 2.40 and 3.51 ± 0.13 mg/100ml, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from the control samples except for sample P_{87.5}L_{12.5}. Lower values were reported by [38, 39] for commercial herbal teas of varying formulations in Poland and North Ossetia, respectively. Zinc is a cofactor of enzymes like oxidoreductases, transferases, isomerases, etc. involved in macronutrient metabolism and cell replication; it is also a signal mediator for the central nervous system [40].

Iron levels ranged from 4.63 ± 0.11 to 8.47 ± 0.18 mg/100ml, with samples P₅₀L₅₀ and P₁₀₀L₀

Table 3 Mineral composition of parquetina and lemongrass composite herbal tea

Minerals (mg/100ml)	P ₁₀₀ L ₀	P _{87.5} L _{12.5}	P ₇₅ L ₂₅	P _{62.5} L _{37.5}	P ₅₀ L ₅₀
Calcium	4.63 ± 1.20 ^c	4.83 ± 1.91 ^c	5.68 ± 0.05 ^b	6.04 ± 0.18 ^a	6.34 ± 0.11 ^a
Magnesium	3.30 ± 0.14 ^c	3.73 ± 0.55 ^{bc}	4.47 ± 0.23 ^{ab}	4.64 ± 0.12 ^a	4.70 ± 0.43 ^a
Potassium	21.19 ± 0.36 ^a	18.56 ± 0.36 ^b	17.13 ± 1.1 ^c	16.42 ± 0.13 ^{cd}	15.06 ± 0.16 ^d
Zinc	2.40 ± 0.00 ^d	2.46 ± 0.08 ^{cd}	2.74 ± 0.14 ^c	3.16 ± 0.18 ^b	3.51 ± 0.13 ^a
Iron	8.47 ± 0.18 ^a	5.57 ± 0.19 ^b	5.48 ± 0.17 ^b	5.26 ± 0.11 ^b	4.63 ± 0.11 ^c
Copper	0.51 ± 0.01 ^a	0.47 ± 0.01 ^b	0.41 ± 0.02 ^c	0.38 ± 0.01 ^c	0.16 ± 0.23 ^d
Sodium	0.15 ± 0.00 ^c	0.20 ± 0.01 ^b	0.21 ± 0.00 ^b	0.21 ± 0.00 ^b	0.23 ± 0.00 ^a

Values are expressed as mean ($n = 3$) ± S.D. Means with the different superscripts along a column are significantly ($P \leq 0.05$) different. P₁₀₀L₀ (control) = Parquetina only; P_{87.5}L_{12.5} = 87.5% Parquetina and 12.5% Lemongrass; P₇₅L₂₅ = 75% Parquetina and 25% Lemongrass; P_{62.5}L_{37.5} = 62.5% Parquetina and 37.5% Lemongrass; P₅₀L₅₀ = 50% Parquetina and 50% Lemongrass.

Table 4 Recommended Daily Intake (RDI) of Minerals for Adults and Amounts Supplied by Composite Herbal Tea from Parquetina and Lemongrass

Minerals	RDI (mg/day)	Amount supplied (%)				
		P ₁₀₀ L ₀	P _{87.5} L _{12.5}	P ₇₅ L ₂₅	P _{62.5} L _{37.5}	P ₅₀ L ₅₀
Calcium	1000	0.46	0.48	0.57	0.60	0.63
Magnesium	310	1.06	1.20	1.44	1.50	1.52
Potassium	4700	0.45	0.39	0.36	0.35	0.32
Zinc	8	30.00	30.75	34.25	39.50	43.88
Iron	8	105.88	69.63	68.50	65.75	57.89
Copper	0.9	56.67	52.22	45.56	42.22	17.78
Sodium	1500	0.01	0.01	0.01	0.01	0.02

P₁₀₀L₀ (control) = herbal tea containing only Parquetina; P_{87.5}L_{12.5} = composite herbal tea containing 87.5% of Parquetina and 12.5% of Lemongrass; P₇₅L₂₅ = composite herbal tea containing 75% of Parquetina and 25% of Lemongrass; P_{62.5}L_{37.5} = composite herbal tea containing 62.5% of Parquetina and 37.5% of Lemongrass; P₅₀L₅₀ = composite herbal tea containing 50% of Parquetina and 50% of Lemongrass

having the lowest and highest value, respectively. All samples are significantly ($P \geq 0.05$) different from the control sample P₁₀₀L₀. The values reported in this study are much higher than those reported in the works [38, 39] for commercial herbal teas of varying formulations in Poland and North Ossetia, respectively. Iron is important in the proper myelination of the spinal cord and proper functioning of the brain, it is also a cofactor of enzymes involved in the synthesis of neurotransmitters, it is necessary for oxygen transport and haemoglobin formation [40].

Copper levels ranged from 0.16 ± 0.23 to 0.51 ± 0.01 mg/100ml, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from the control sample P₁₀₀L₀. [38, 39] reported lower values for commercial herbal teas of varying formulations in Poland and North Ossetia, respectively. Copper is necessary for the absorption of iron, bone growth and formation, formation of myelin sheaths in the nervous system and for proper functioning of haematological and neurologic systems [40].

Sodium levels ranged between 0.15 ± 0.00 and 0.23 ± 0.00 mg/100ml, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively. Samples are significantly ($P \leq 0.05$) different from the control sample P₁₀₀L₀. Similar results were observed in the work of [38] for commercial herbal teas of varying formulations in Poland.

Sodium helps to maintain the osmotic pressure of body fluids, activates nerve and muscle function, transmits nerve impulses [40].

The calcium, magnesium, zinc and sodium contents of the composite herbal tea samples significantly ($P \leq 0.05$) increased with increasing amounts of Lemongrass in the sample formulation, this may be because Lemongrass contributed more of these minerals in the respective samples. To the contrary, potassium, iron and copper significantly reduced ($P \leq 0.05$) with decreasing amounts of Parquetina in the sample formulation, indicating that Parquetina may have contributed more of these minerals in the respective samples. Table 3 shows that the most abundant mineral in the composite herbal tea samples was potassium. This is similar to the findings of [38, 39]. Nevertheless, the composite herbal tea cannot be said to be rich in potassium as they contribute minimally to the recommended daily intake (Table 4). On this basis, the composite herbal tea samples are rich in iron, copper and zinc, as they contribute greatly to the recommended daily intakes of these minerals.

Antioxidant capacities

The antioxidant capacity of the samples ranged from 17.77 ± 0.11 to $40.96 \pm 0.63\%$, with samples P₁₀₀L₀ and P₅₀L₅₀ having the lowest and highest values, respectively.

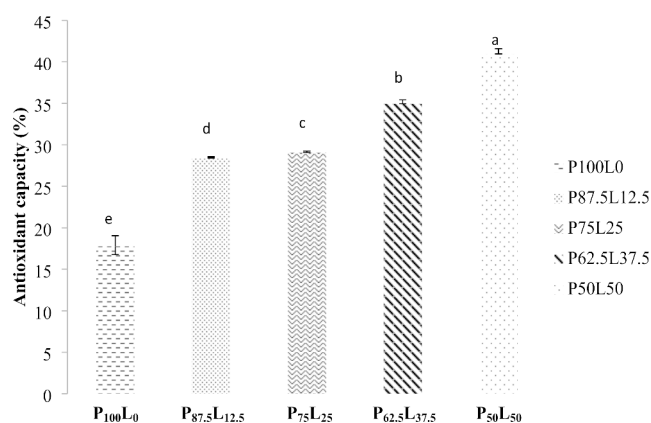


Fig. 1 Antioxidant capacity of parqueting and lemongrass composite herbal tea

Values are expressed as mean ($n=3$) $\pm$ S.D. Means with the different superscripts along a column are significantly ($P \leq 0.05$) different. P₁₀₀L₀ (control)=Parquetina only; P_{87.5}L_{12.5} = 87.5% Parquetina and 12.5% Lemongrass; P₇₅L₂₅ = 75% Parquetina and 25% Lemongrass; P_{62.5}L_{37.5} = 62.5% Parquetina and 37.5% Lemongrass; P₅₀L₅₀ = 50% Parquetina and 50% Lemongrass.

All samples are significantly ($P \leq 0.05$) different from the control sample P₁₀₀L₀. Antioxidants are compounds that have the ability to inhibit oxidative reactions that can produce free radicals and reactive oxygen species (ROS) that damage cells. Free radicals are molecules with valence electrons, thus, they are highly reactive and capable of initiating processes that are detrimental to cells [41].

The findings reported in Fig. 1 show that the composite herbal tea samples exhibited radical scavenging activities, and thus, have antioxidant properties. The antioxidant capacities of the composite herbal tea samples is seen to significantly ($P \leq 0.05$) increase with increasing amounts of Lemongrass at a positive correlation level of $r=0.970^{**}$. This can be attributed to a synergy between the two plants and may probably be the reason why sample P₅₀L₅₀ had the highest antioxidant capacity among the samples. This same trend was reported by [42] who tested the synergism between the antioxidant activities of *Camellia sinensis* and some herbs, and by [43] who investigated antioxidant synergy between *Osmanthus fragrans* flowers and *Camellia sinensis*.

The antioxidant capacity of plants is dependent on the amount and types of phytochemicals inherent in them [44]. Correlation studies between the antioxidant capacities and phytochemical compositions of the composite herbal tea samples indicate that phenols have a strong positive correlation ($r=0.832^{**}$), with antioxidant capacity. The same goes for flavonoids at a correlation coefficient value of $r=0.865^{**}$, alkaloids at $r=0.894^{**}$, tannins at $r=0.816^{**}$, terpenoids at $r=0.913^{**}$. On the contrary, cardiac glycosides and saponins have a strong negative correlation ($r = -0.957^{**}$ and $r = -0.948^{**}$, respectively) with antioxidant capacity. By

Table 5 Microbiological quality of composite herbal tea from parqueting and lemongrass

Samples	TBC (cfu/g) AL = $< 10^7$	TFC (cfu/g) AL = $< 10^5$	TCC (cfu/g) AL = $< 10^3$
P ₁₀₀ L ₀	$8.15 \pm 12.02 \times 10^4$	$2.55 \pm 2.12 \times 10^4$	$6.5 \pm 0.71 \times 10^2$
P _{87.5} L _{12.5}	$8.05 \pm 7.78 \times 10^4$	$3.05 \pm 3.54 \times 10^4$	$7.5 \pm 0.71 \times 10^2$
P ₇₅ L ₂₅	$8.95 \pm 16.26 \times 10^4$	$2.85 \pm 2.12 \times 10^4$	$5.5 \pm 2.12 \times 10^2$
P _{62.5} L _{37.5}	$8.75 \pm 9.19 \times 10^4$	$2.55 \pm 0.71 \times 10^4$	$6.5 \pm 2.12 \times 10^2$
P ₅₀ L ₅₀	$8.75 \pm 4.95 \times 10^4$	$3.05 \pm 2.12 \times 10^4$	$7.0 \pm 2.82 \times 10^2$

Values are expressed as mean ($n=3$) $\pm$ S.D. Means with different superscripts along a column are significantly ($P \leq 0.05$) different. TBC=total bacterial count; TFC=total fungi count; TCC=total coliform count; AL=acceptable limits; P₁₀₀L₀ (control)=Parquetina only; P_{87.5}L_{12.5} = 87.5% Parquetina and 12.5% Lemongrass; P₇₅L₂₅ = 75% Parquetina and 25% Lemongrass; P_{62.5}L_{37.5} = 62.5% Parquetina and 37.5% Lemongrass; P₅₀L₅₀ = 50% Parquetina and 50% Lemongrass.

implication, cardiac glycosides and saponins concentrations had no effect on the antioxidant capacities of the composite herbal tea samples.

Microbiological status

The total bacterial count (TBC) of the samples represented in Table 5 ranged from $8.05 \times 10^4 \pm 7.78$ to $8.95 \times 10^4 \pm 16.26$ cfu/g, with samples P_{87.5}L_{12.5} and P₇₅L₂₅ having the lowest and highest values, respectively. Total fungal count (TFC) ranged from $2.55 \times 10^4 \pm 0.71$ to $3.05 \times 10^4 \pm 3.54$ cfu/g, with samples P_{62.5}L_{37.5} and P_{87.5}L_{12.5} having the lowest and highest values, respectively. Total coliform count (TCC) ranged from $6.50 \times 10^3 \pm 0.71$ to $8.00 \times 10^3 \pm 4.24$ cfu/g, with samples P₁₀₀L₀ and P_{87.5}L_{12.5} having the lowest and highest values, respectively. No faecal coliforms were detected and no significant ($P \leq 0.05$) difference was recorded among samples. This was expected as samples were prepared from the same batch. The microbiological quality of foods is a vital criterion in food safety and this is due to the health risks posed by microbial contamination. Therefore, foods must be assessed to ensure that good hygiene practices have been employed in their production and that they are safe for consumption [45]. The microbiological quality of the composite herbal tea show that TBC, TFC and TCC are all within their acceptable limits as specified by Tea and Herbal Infusions, Europe [46] and are therefore, safe for consumption.

Sensory properties

The sensory appeal of food products, is an important consideration in new product development as consumers are generally unwilling to accept foods with poor sensory appeal [8]. Results for the sensory evaluation of the composite green tea from Parquetina and Lemongrass are represented in Fig. 2.

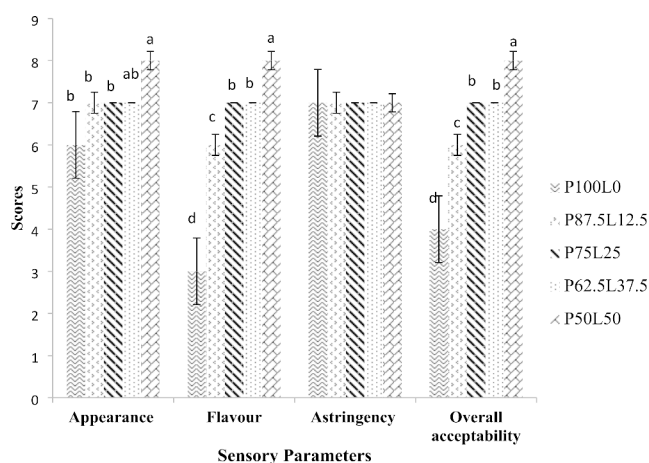


Fig. 2 Sensory properties of parquetina and lemongrass composite herbal tea

Values are scored on 9-point Hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely). Values are represented as mean $\pm$ S.D. Means with different superscripts are significantly ($P \leq 0.05$) different. $P_{100}L_0$ (control) = Parquetina only; $P_{87.5}L_{12.5}$ = 87.5% Parquetina and 12.5% Lemongrass; $P_{75}L_{25}$ = 75% Parquetina and 25% Lemongrass; $P_{62.5}L_{37.5}$ = 62.5% Parquetina and 37.5% Lemongrass; $P_{50}L_{50}$ = 50% Parquetina and 50% Lemongrass.

Samples were scored for appearance, flavour, astringency and overall acceptability. Appearance is the first noticeable attribute perceived by the human senses and therefore, plays a major role in the final selection of that food. Flavour is the sensory attribute which combines the properties of taste and smell as perceived by the mouth and nose. Astringency describes a dry puckering sensation perceived by the mouth and overall acceptability generally describes how appealing the product is to the consumers [47, 48].

Appearance of the samples scored between 6 ± 0.83 and 8 ± 1.08 , with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest, respectively. Only samples $P_{100}L_0$ and $P_{50}L_{50}$ are significantly ($P \leq 0.05$) different. Flavour scores were between 3 ± 1.38 and 8 ± 0.91 , with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest scores, respectively. Scores are significantly ($P \leq 0.05$) different, except for samples $P_{75}L_{25}$ and $P_{62.5}L_{37.5}$. Astringency scores varied between 7 ± 0.79 and 7 ± 0.87 ; values are not significantly ($P \geq 0.05$) different. Overall acceptability scores varied from 4 ± 0.95 to 8 ± 0.93 , with samples $P_{100}L_0$ and $P_{50}L_{50}$ having the lowest and highest scores, respectively. Scores are significantly ($P \leq 0.05$) different except for samples $P_{75}L_{25}$ and $P_{62.5}L_{37.5}$. Generally, Appearance scores ranked high on the hedonic scale meaning that the appearance of the samples was accepted. Sample $P_{50}L_{50}$ was significantly ($P \leq 0.05$) higher than the rest, this may probably be due to the lightness of its colour. Flavour scores varied between samples. Sample $P_{100}L_0$ scored significantly ($P \leq 0.05$) lower, hence, it was the

least preferred. This may be attributed to its bland flavour which may be indicative of the absence of distinct flavour compounds. Sample $P_{50}L_{50}$ scored significantly ($P \leq 0.05$) higher than the other samples, and by implication, was the most preferred sample. The increase in the flavour scores of the composite herbal tea sample as compared to the control sample $P_{100}L_0$ is indicative of the presence of distinct flavour compounds in Lemongrass. Astringency scores were not significantly ($P \geq 0.05$) different and all samples ranked high on the hedonic scale. This may be due to the alkaline pH of the samples as astringency is usually linked to highly acidic foods. Overall acceptability score shows that the most preferred sample was $P_{50}L_{50}$ and the least preferred was $P_{100}L_0$. Similar findings have been reported for the sensory attributes of Lemongrass tea [27;27], but there are no reports on the sensory attributes of Parquetina. To the best of our knowledge, this study is the first to document the sensory attributes of Parquetina tea.

Conclusion

Composite herbal teas were produced from five formulations of Parquetina and Lemongrass. The physico-chemical, phytochemical, mineral compositions, antioxidant capacities and sensory attributes of the formulations were examined. The composite herbal tea formulation with 50% Parquetina and 50% lemongrass ($P_{50}L_{50}$) had the highest water soluble extracts and infusion rate at 72.37% and 114.74 mg/min, respectively; and lowest turbidity (31.11%) and pH (7.08). It also had the highest phenol (0.90 mgGAE/100ml), alkaloid (0.79 mg/100 ml), flavonoid (0.58 mgQE/100ml) and terpenoid (0.25 mg/100ml) contents. In addition, it had the highest calcium (0.63 mg/100ml), magnesium (1.52 mg/100ml), zinc (43.88 mg/100ml) and sodium (0.02 mg/100ml), and highest antioxidant capacity (40.96%). The microbiological quality of the composite herbal tea shows that total bacteria count, total fungal count and total coliform count were all within their respective acceptable limits. Sensory evaluation showed that the most preferred sample was $P_{50}L_{50}$ (50% parquetina and 50% lemongrass). This study provides valuable information in the use of Parquetina and Lemongrass to develop a composite herbal tea that has good physico-chemical properties, phytochemical and mineral compositions, antioxidant capacities and sensory attributes. Therefore, herbal tea producers would find this information beneficial in the aspect of formulating herbal teas that would be nutrient dense and also appealing to the consumers.

Author contributions Conceptualization: Victoria Auhoiza Joshua, Rowland Monday-Ojo Kayode and Mayowa Saheed Sanusi. Methodology: Victoria Auhoiza Joshua, Rowland Monday-Ojo Kayode and Mayowa Saheed Sanusi.

Formal analysis and investigations: Victoria Auhoiza Joshua, Olufunmilola Adunni Abiodun, Stephen Orobola Olabanji and Ojochenemi Rebecca Egwumah.

Writing – original draft: Victoria Auhoiza Joshua, Rowland Monday-Ojo Kayode and Olufunmilola Adunni Abiodun.

Writing – review and editing: Bukola Idowu Kayode, Ojochenemi Rebecca Egwumah and Stephen Orobola Olabanji.

Data analysis: Victoria Auhoiza Joshua and Bukola Idowu Kayode.

Supervision: Victoria Auhoiza Joshua, Rowland Monday-Ojo Kayode and Mayowa Saheed Sanusi.

Funding/support statement The authors did not receive any funds, grants or other supports for the work reported in this paper.

Declarations

Ethical approval and informed consent Ethical approval was obtained from the University of Ilorin Ethical Review Committee and the reference number UERC/ASN/2021/2041 was issued.

Competing interests The authors declare that they have no financial or non-financial interests to disclose.

References

1. M. Nicoletti, *J. Int Food Sci Nutr.* (2012). <https://doi.org/10.3109/09637486.2011.628012>
2. C. Ravikumar, *J. Pharm. Sci. Res.* **6**, 236–238 (2014)
3. S. Oguntola, Scientists validate herbal cure for diarrhoea. (Nigerian Tribune 2019), Retrieved from <https://tribuneonline.ng.com/scientists-validate-herbal-cure-for-diarrhoea/amp/> Accessed June 2022
4. O.I. Akinyemi, E.O. Dada, *ARPN: J. Agric. Biol. Sci.* **8**, 732–739 (2014)
5. B.V. Owoyele, A.B. Nafiu, I.A. Oyewole, L.A. Oyewole, A.O. Soladoye, *J. Ethnopharmacol.* **122**, 86–90 (2008)
6. N.A. Imaga, G.O. Gbenle, V.I. Okochi, S. Adenekan, *Sci. Res. Essays* **5**, 2201–2205 (2010)
7. O.L. Olayinka, E.A.G. Khalil, S.A. Atunwa, A.A. Abdullahi, M.K. Salawu, K.A.T. Ogunwale et al., *Afr. J. Pharm. Pharmacol.* (2018). <https://doi.org/10.5897/AJPP2017.4879>
8. N.E.A. De-Heer, Formulation and sensory evaluation of herb tea from Moringa oleifera, Hibiscus sabdariffa and Cymbopogon citratus. (DATAD-R 2011). Retrieved from <http://hdl.handle.net/123456789/2249>. Accessed 17 April 2021
9. G. Shah, R. Shri, V. Panchal, N. Sharma, B. Singh, A.S. Mann, *J. Adv. Pharm. Technol. Res.* (2011). <https://doi.org/10.4103/2231-4040.79796>
10. E. Majewska, M. Koz, E. Gruczy, D. Kowalska, K. Tarnowska, *Pol. J. Food Nutr. Sci.* (2019). <https://doi.org/10.31883/pjfn/113152>
11. F. Malongane, L. McGaw, F.N. Mudau, *J. Sci. Food Agric.* (2017). <https://doi.org/10.1002/jsfa.8472>
12. V. Joshua, R. Kayode, M. Sanusi, A. Awoniyi, O. Abiodun, B. Kayode, *Alq J. Med. App Sci.* (2022). <https://doi.org/10.5281/zenodo.6039672>
13. K.C. Yadav, A. Parajuli, B.B. Khatri, L.D. Shiwakoti, *J. Food Qual.* (2020). <https://doi.org/10.1155/2020/8874271>
14. K. Chew-Shio-Heong, N.H. Bhupinder, A.K. Alias, F. Ariffin, *Am. J. Food Technol.* (2011). <https://doi.org/10.3923/ajft.2011.581.593>
15. B.E. Orimadegun, E.B. Bolajoko, A.A. Onyeaghala, O.O. Ademola-Aremu, *J. Med. Plant. Res.* (2018). <https://doi.org/10.5897/JMPR2018.6578>
16. Z. Tofighi, G.N. Saeidi, A. Hadjiakhoondi, N. Yassa, *Res. J. Pharmacog* **3**, 25–31 (2016)
17. A.B.M. Uddin, R.S. Khalid, M. Alaama, A.M. Abdulkader, A. Kasmuri, S.A. Abbas, *J. Anal. Sci. Technol.* (2016). <https://doi.org/10.1186/s40543-016-0085-6>
18. T. Moodley, E.O. Amonsou, S. Kumar, *J. Food Sci. Technol.* (2015). <https://doi.org/10.1007/s13197-015-1870-8>
19. F. Carraturo, O. Castro, J. Troisi, A. Luca, A. Masucci, P. Cennamo et al., *BMC Microbiol.* (2018). <https://doi.org/10.1186/s12866-017-1142-z>
20. ISO. International Standards Organization. (2011). Green Tea - Definition and Basic Requirement. 11287
21. M. Adnan, A. Ahmad, A. Ahmed, N. Khalid, I. Hayath, I. Ahmed, *Pak J. Bot.* **45**, 901–907 (2013)
22. S. Akyuz, A. Yarat, *OHDMBSC.* **9**, 75–78 (2010)
23. L.B.F. Lunkes, L.N. Hashizume, *Rev. Gaucha Odontol.* (2014). <https://doi.org/10.1590/1981-8637201400010000092623>
24. D. Wu, D.W. Sun, *Trends Food Sci Tech.* (2013). <https://doi.org/10.1016/j.tifs.2012.08.004>
25. V.S.P. Chaturvedula, I. Prakash, *J. Med. Plant. Res.* (2011). <https://doi.org/10.5897/JMPR.9001187>
26. N. Pathaw, K.S. Devi, R. Sapam, J. Sanasam, S. Monteshori, S. Phurailatpam, H.C. Devi, W.T. Chanu, B. Wangkhem, N.L. Mangang, *Front. Nutr.* (2022). <https://doi.org/10.3389/fnut.2022.988964>
27. J. Ndife, N.C. Uka, N.A. Ukom, *Food Res.* (2019). [https://doi.org/10.26656/fr.2017.3\(5\).040](https://doi.org/10.26656/fr.2017.3(5).040)
28. C. Egbuna, J.C. Ifemeje, *Int. Org. Scientific Res. - J. Pharm. Biol. Sci.* (2015). <https://doi.org/10.9790/3008-10231019>
29. M. Marrelli, F. Conforti, F. Araniti, G.A. Statti, *Molecules.* (2016). <https://doi.org/10.3390/molecules21101404>
30. A.B. Yusuf, A.A. Turaki, A.A. Adetunji, *Haya: Saudi J Life Sci.* (2022). <https://doi.org/10.36348/sjls.2022.v07i05.002>
31. A.P. Ambrosy, J. Butler, A. Ahmed, M. Vaduganathan, D.J. VanVeldhuisen, W.S. Colucci et al., *J. Am. Coll. Cardiol.* (2014). <https://doi.org/10.1016/j.jacc.2014.01.051>
32. NIDDKD, Cardiac glycosides. (LiverTox-NCBI Bookshelf, 2012), www.ncbi.nlm.nih.gov/books/NBK548418/#!po=96.6667. Accessed on 12 April 2021
33. D. Ghosh, *Int. J. Pharm. Sci. Rev. Res.* **4**, 40–44 (2015)
34. Y. Zhu, C.Y. Shao, H.P. Lv, Y. Zhang, W.D. Dai, L. Guo et al., *J. Chromatogr. A.* (2017). <https://doi.org/10.3864/j.issn.0578-1752.2017.06.012>
35. B.H. Paschoalinotto, M.I. Dias, J. Pinela, T.C.S.P. Pires, M.J. Alves, A. Mocan, R.C. Calehlha, L. Barros, R.P. Ineu, I.C.F.R. Ferreira, *Foods.* (2021). <https://doi.org/10.3390/foods10020475>
36. J.O. Odukoya, J.O. Odukoya, A.A. Oshodi, *Eur. J. Pure Appl. Chem.* **5**, 18–31 (2018)
37. S.S. Ranade, P. Thiagarajan, *Int. J. Pharm. Sci. Rev. Res.* **35**, 162–167 (2015)
38. W. Samolinska, B. Kiczorowska, M. Kwiecien, E. Rusinek-Prystupa, *Biol. Trace Elem. Res.* (2017). <https://doi.org/10.1007/s12011-016-0790-4>
39. Y. Lavrinenko, A. Plieva, I. Zinicovskaia, G. Hristozova, M. Frontasyeva, K. Tkachenko, D. Dogadkin, I. Gromyak, V. Kolotov, *Agriculture.* (2021). <https://doi.org/10.3390/agriculture11090841>
40. K.O. Soetan, C.O. Olaiya, O.E. Oyewole, *Afr. J. Food Sci.* **4**, 200–222 (2010)
41. A.V. Badarinath, K.M. Rao, C.M.S. Chetty, S. Ramakanth, T.V.S. Rajan, K. Gnanaprakash, *Int. J. Pharmatechnol Res.* **2**, 1276–1285 (2010)
42. D.P.I. Jain, S.S. Pancholi, R. Patel, *J. Adv. Pharm. Technol. Res.* (2011). <https://doi.org/10.4103/2231-4040.85538>

43. S. Mao, K. Wang, Y. Lei, S. Yao, W. Lu, W. Huang, *Sci. Rep.* (2017). <https://doi.org/10.1038/srep46501>
44. A.O. Ayoola, O. Akinloye, O. Oguntibeju, A.A. Odetola, *Afr. J. Biotechnol.* (2011). <https://doi.org/10.5897/AJB10.1622>
45. E. Milani, *Saffron*. (S. Woodhead Publishing, 2020), pp. 307–20. <https://doi.org/10.1016/B978-0-12-818638-1.00019-8>
46. THIE. Tea and Herbal Infusions, Europe. THIE's Recommended Microbiological Specification for Herbal Infusions (Dry). **8**, 1–7 (2018)
47. Y. Jiang, N.N. Gong, H. Matsunami, *Chem. Senses.* (2014). <https://doi.org/10.1093/chemse/bju021>
48. M.K. Sharif, M.S. Butt, H.R. Sharif, M. Nasir, *Handbook of Food Science and Technology* (Faisalabad, Pakistan, 2017), pp. 362–386
49. C.S. Dzah, *J. Food Nutr Sci.* (2015). <https://doi.org/10.11648/j.jfns.20150303.19>
50. P. Mabai, A. Omolola, A.I.O. Jideani, *J. Food Res.* (2018). <https://doi.org/10.5539/jfr.v7n2p68>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.