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COMPARATIVE EVALUATION OF THE EFFECTS OF PRETREATMENTS ON THE NUTRITIONAL AND CHEMICAL PROPERTIES OF GINGER LEAF-BASED HERBAL TEA

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ABSTRACT

There is increasing awareness and acceptance of herbal teas because of their contribution to nutrition and health. The use of ginger (*Zingiber officinale*) leaves as tea in some communities has been reported. While many research efforts have focused on ginger rhizomes, there is a limited report on ginger leaves' nutritional, antioxidant properties and also what effect application of different heat pretreatments will have on the final product. The present study sought to develop a ginger leaf-based herbal tea and examine the effects of postharvest pretreatments such as steam blanching before drying, hot water blanching before drying and directly drying on the nutritional and chemical properties of the tea. Fresh green leaves were sorted, washed and drained. A batch of the leaves was evenly steam blanched at 100^0C for 5 minutes before drying, another set was dipped in boiling water at 100^0C for 3 minutes and the last batch was dried directly at 55^0C under standard conditions. The dried leaves were milled, packed in tea bags and a sample each was evaluated for its proximate, mineral, vitamin C, phytochemicals and antioxidant properties following standard procedures. The results showed that steam blanching significantly ($p<0.05$) increased the protein, fat, sodium, potassium, saponin and the antioxidant potential (ferric reducing antioxidant power) compared to those that were hot water-blanched before drying and those dried directly. However, vitamin C, tannin, phytate, oxalate and zinc contents decreased significantly when compared with the fresh leaves. The free radical scavenging activity examined using DPPH activity, phenols and flavonoids did not vary significantly between the steam blanched and fresh leaves. These findings showed that steam blanching of ginger leaves before drying for consumption as a functional beverage is beneficial in terms of nutrient and antinutrient properties compared to hot water blanching before drying and direct drying. Therefore, this method of processing could be adapted for improved nutrition.

Key words: Tea, pretreatments, steam blanching, ginger leaves, nutritional, antioxidant potential

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INTRODUCTION

Ginger (*Zingiber officinale Roscoe*), used as both herb and a spice, is a perennial crop which belongs to the family Zingiberaceae and is native to South-eastern Asia. In the sixteenth century, ginger was introduced to West Africa by the Portuguese and it found its way into Nigeria in 1927 [1]. Its nutritive value and ethno-medicinal application can be traced as far back into ancient Chinese and Middle Eastern periodicals [2]. It was one of the randomly and often used herbs in Ayurvedic medicinal practices. It was and is still being used orally, intramuscularly and topically in various formulations all over the world [3].

Gingers have a wide variety of usage as every part of the plant is highly beneficial from the leaves, rhizomes to the root be it in raw or processed form [4]. Ginger leaves have been reported for their use as flavor for wild meat and fish dishes, eaten raw as in salad and decoctions from various species are being used in treatment of flatulence, as antidote to poisons, in a mixture with other aromatic herbs to cure postpartum body odour, laxative, wound treatment and management of sore joints [3]. Herbal teas are being made from leaves of *Alpinia zerumbet* (a specie of ginger) in Japan and consumed for their hypotensive, anti-inflammatory, diuretic and anti-ulcerogenic properties [5]. Gingers have also been reported for their antioxidant, anti-obesity, antimicrobial, anticancer, cardiovascular protective and antiemetic properties [6, 7]. Phytochemical studies of ginger leaves have resulted in isolation of flavonoids [5], phenolic acids, diterpenes, pyrones [8], polysaccharides, lipids and raw fibers. Some of the isolated compounds include; rutin, kava pyrones, kaempferol, 3-0- glucuronide, p-hydroxybenzoic acid, ferulic acid, chlorogenic acid [9], 3-methoxyflavone, β- sitosteryl galactoside and other flavonoid glycosides.

Bender's dictionary of Nutrition and Food Technology defines herbal tea as an infusion made from herbs, fruits, flowers, stems, roots, and other plant parts [10]. Herbal teas otherwise known as functional beverages, have been consumed since time immemorial for sensory and medicinal purposes. In countries such as India and Africa, majority of the population resort to herbal formulations in management or treatment of various health challenges and most use these herbs alongside prescribed modern tablets. Polyphenol compounds, which are excellent antioxidants present in substantial quantities in most herbs and spices, have roused a lot of international research interest as medicinal prospects [11].

While recent research focuses on validation of various nutritional and antioxidant benefits of teas from leaves of ginger, it is not known what the effects of different

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heat treatments will have on the final product. Therefore, this study sought to examine the effects of pretreatments on the quality parameters of ginger leaf tea.

MATERIALS AND METHODS

Plant material

Fresh green leaves of *Zingiber officinale* Roscoe (Ginger) were harvested from the orchard of the National Horticultural Research Institute, Nigeria between the hours of 6.30 – 7.30 am and sorted to remove all extraneous materials.

Preparation of herbal tea samples

The leaves were sorted to remove any foreign material, washed under running water and drained. They were then cut into about 3 cm pieces using a stainless-steel knife and were divided into three batches. One batch of leaves was steam blanched at 100 ^{0}C for 5 min, after which they were dried at 55 ^{0}C using a food dehydrator (Excalibur, USA). The second batch of leaves was dipped in boiling water at 100 ^{0}C for 3 min and drained before drying at the same temperature for 6 h. The third batch of leaves was air-dried. The leaves were then milled using a blender (Silver crest HP Grinder- 5000 W) and the dried leaves were stored in airtight containers for further analysis.

Quality parameter analysis on the dried ginger leaves

Proximate analysis

Total ash, crude protein, crude fat, crude fibre, moisture and carbohydrate were determined using the standard method of AOAC [12].

To determine total ash, 2 g of each sample was weighed into pre-weighed silica crucibles then charred at high temperatures over a heater. Afterwards, it was ignited in a muffle furnace at 550 ± 50 ^{0}C for 3 h. the remaining content in the crucible was recorded as the ash content of the sample.

Crude protein was determined by micro-Kjedahl method (N × 6.25), where 'N' is the total nitrogen content. One gram of each sample was weighed and added into a Kjedahl flask containing 20 ml concentrated sulphuric acid. A mixture of 2 g of K_2SO_4 and $CuSO_4$ in ratio 9:1 was added as catalyst. The flask was then heated for about 30 min until carbon particles were observed. The flask was then allowed to cool, contents were repeatedly washed with distilled water after which they were transferred into a volumetric flask and made up to 250 ml with distilled water. Ten millilitres of the digested mixture was passed through micro-Kjedahl distillation apparatus using a saturated solution of 40 % NaOH as alkali. Fifty milliliters of liberated ammonia was collected into a flask containing 20 ml of 2 % boric acid

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using Tashiro as the indicator. The resultant distillate was then titrated against 0.01N H_2SO_4. Crude protein (%) was determined as follows:

$$\text{The percentage Crude Protein (\%)} = \frac{0.00014 \times V \times 100 \times 250 \times 6.25}{Z \times W} \times 100$$

Where
V = Volume of 0.01N H_2SO_4 neutralized by NH_3
W =Weight of the sample (g)
Z = Volume of aliquot taken for distillation
Crude fat content was determined by Soxhlet fat extraction method. Two grams of sample was weighed into an extraction thimble and covered with absorbent cotton. Fifty millilitres petroleum ether was added to a pre-weighed cup. Both thimble and cup were attached to the extraction unit. The sample was subjected to extraction with solvent for 30 min followed by rinsing for 1½ h. The petroleum ether was evaporated from the cup passing through the condensing column. The residual fat extract in the cup was calculated using the following formula:

$$\text{The percentage Crude fat (\%)} = \frac{\text{Extracted fat}}{\text{Sample weight}} \times 100$$

Crude fibre was determined by hydrolysis. Two grams of each of the samples were weighed into 500 ml beaker of water. The content was boiled for 30 min. It was then filtered through a fluted funnel and was repeatedly washed with boiling water until the washed-out water was no longer acidic (litmus paper test). The samples were boiled for 30 min with 200 ml sodium hydroxide solution, and filtered while hot using muslin cloth; then rinsed with one percent (1 %) HCl and finally, with methylated spirit. The residue that was obtained was collected and dried in an oven for 30 min. The contents were cooled in a desiccator and then weighed. These were taken to the furnace for ashing at 550 ^{O}C for 30 min. The ashed samples were removed from the furnace after the temperature dropped to 200 ^{O}C and put into the desiccator and later weighed. The loss in weight was taken as the crude fibre content.

$$\text{The percentage crude fibre (\%)} = \frac{\text{Total weight of fibre}}{\text{Weight of the sample}} \times 100$$

Moisture content was determined by gravimetric method. Five grams of each sample was weighed into a pre-weighed moisture can and dried in an oven at 105 ^{0}C for 3 h. It was allowed to cool in a desiccator and then weighed. It was then returned into the oven for 1 h, cooled and reweighed. This process was repeated

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hourly until a stable weight was recorded. Moisture content was calculated as follows:

$$\text{Moisture content (\%)} = \frac{\text{weight of sample before drying - weight of sample after drying}}{\text{weight of sample before drying}} \times 100$$

Carbohydrate content was determined as follows:

Total carbohydrate = 100 – (ash % + Protein % + fat % + moisture % + fibre %)

Vitamin C

Ascorbic acid was determined by 2, 6 dichlorophenolindophenol (DCPIP) assay as described by Adeboyejo *et al*. [13].

Sample was diluted in 0.1 M citric acid and 0.1 M sodium citrate buffers at ratio 1:40 and 1:20, respectively. Two milliliters of DCPIP was added to 10 ml of each sample and the tube immediately capped. The spectrophotometer (T70 UV-VIS spectrophotometer, PG instruments, Alma Park, UK) absorbance was read at 520 nm within 5 min of adding DCPIP solution.

The ascorbic acid content was calculated using the calibration curve, prepared from L-ascorbic acid and values were expressed as mg/ 100 g of sample.

Total Phenol Content

The total phenol content in herbal ginger tea sample was determined by Folin-Ciocalteau method [14]. To 0.5 g of sample in a test tube, 2.5 ml of 10 % Folin C reagent (Sigma Chemical, St. Louis, Missouri, USA) and 2 ml of 7.5 % Na_2CO_3 were added. The mixture was allowed to stand for 30 min at room temperature and absorbance was read at 765 nm. The total phenol content of herbal tea sample was expressed as mg of gallic acid equivalents (mg GAE)/ 100 g of sample.

Total Flavonoid Content

The total flavonoids content was determined using a procedure described by Wickramasinghe *et al*. [15]. A sample of 0.1 g was added to 0.1 ml of 2 % $AlCl_3$ solution in methanol and the mixture was allowed to stand in the dark at room temperature for 10 min. Absorbance was measured at 415 nm using UV-VIS Spectrophotometer. Results were expressed as mg of quercetin equivalents (mg QE) / 100 g of tea sample.

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Total antioxidant activity (DPPH method)

The DPPH assay was performed according to procedure as described by Nuengchamnong and Ingkaninan [16] with slight modifications. A solution of 0.002 % µM of 1, 1-diphenyl-1, 2-picrylhydrazl (DPPH) was prepared by dissolving 0.002 g of DPPH in 80 % ethanol. Then, 0.40 ml of sample was added to 7.6 ml of 0.002 % DPPH and the mixture was left in the dark for 30 min. Absorbance was measured using UV-VIS Spectrophotometer at 517 nm where ethanol was used as blank. The results were expressed as % of radical scavenging activity using the following formula:

$$\% \text{ Scavenging activity} = \frac{(A_0 - A_s)}{A_0} \times 100$$

Where, A_0 = absorption control, A_s = absorption of the test solution.

Tannin Content

The tannin content of the sample was determined as reported by Adeboyejo *et al*. [13]. From each sample, 0.5 ml was pipetted in a test tube and mixed with 10 ml of 80 % ethanol. The mixture was thoroughly shaken and allowed to stand for 1 h. One millilitre was then pipetted into another test tube to which 5 ml distilled water, 2 drops of $FeCl_2$ in 0.1 M HCl was added. The mixture was shaken after which 4 drops of potassium ferrocyanide was added. The absorbance was read in UV-VIS spectrophotometer at 620 nm.

Ferric Reducing Antioxidant Power (FRAP)

Ferric reducing antioxidant power (FRAP) was determined according to method as described by Benzie and Strain [17] with slight modifications.

To 5 ml of 10mM 2, 4, 6-tris (2-pyridyl)-1,3,5-triazine (TPTZ) solution in 40 mM hydrochloric acid solution, 5 ml of 20 mM $FeCl_3.6H_20$ solution and 50 ml of 300 mM acetate buffer solution (pH 3.6) were added and the mixture was incubated at 37 °C. This is the FRAP reagent. Sample extract of 0.15 ml was mixed with 2.85 ml of FRAP reagent for 30 min under dark conditions. The absorbance of 0.20 ml of the mixture was determined at 593 nm (T70 UV-VIS spectrophotometer, PG instruments, Alma Park, UK). The FRAP values were compared with quercetin (mmol/ml).

Saponin

Saponin content was determined according to methods described by Ilodibia [18]. From each sample, 5 g was measured and dissolved in 50 ml of 20 % v/v ethanol. The resultant suspension was then heated over a hot water bath at 55 ^{0}C for the

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next 4 h with continuous stirring. Afterwards, it was filtered, residue extracted and the procedure repeated. Resultant extract was then concentrated to 20 ml in a hot water bath. This was then added to 10 ml of diethyl ether in a separating funnel and the mixture shaken vigorously. The aqueous layer was collected, 20 ml but-1-ol was added and then washed twice with 10 ml of 5 % w/v aqueous sodium chloride. The resultant mixture was oven dried till constant weight was obtained and saponins content was calculated according to the formula:

$$\% \text{ Saponin} = \frac{\text{weight of final filtrate}}{\text{Weight of sample}} \times 100$$

Phytate

Phytate content was determined by a method described by Adeboyejo *et al*. [13]. From the sample, 2 ml was pipetted and added to 40 ml of 2.4 % HCl (68.6 ml of 35 % hydrochloric acid in 1 L of D_2O) while constantly shaking at 25 ^oC for 3 h. It was then filtered and absorbance was read at 640 nm.

Oxalate

Oxalate content was determined according to a method described by Adeniyi *et al*. [19]. From each sample, 2 g was weighed, then digested with 10 ml 6 M HCl for 1 h and made up to 250 ml. Digested mixture was filtered and pH of the filtrate was adjusted with conc. NH_4OH solution until a color change from pink to faint yellow was observed. Thereafter, 10ml of 5 % $CaCl_2$ solution was added to the filtrate to precipitate the insoluble oxalate. The resultant suspension was centrifuged at 2500 rpm. Afterwards, the supernatant was decanted and 10 ml of 20 % (v/v) H_2SO_4 was added to completely dissolve the precipitate. The solution was then made up to 300 ml with 20 % (v/v) H_2SO_4. From the mixture, an aliquot of 125 ml was heated until near boiling and this was titrated against 0.05 M of $KMNO_4$ till a persistent faint pink color was observed and the burette reading was read and recorded. The oxalate content was calculated using the titre value:

$$\text{Redox reaction: } 2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$$

Minerals

From each of the samples, 5.0 g was weighed into clean porcelain crucibles and subjected to dry ashing at 550 ^0C for 5 h. The ash obtained was dissolved in 5.0 ml of HNO_3/HCl (1:2). The resultant mixture was then gently heated until the brown fumes were completely dissipated. This was then transferred into a conical flask and 5.0 ml of distilled water was added and the solution heated until it turned colorless. The mineral solution was filtered into 25.0 ml volumetric flask and made

up to mark with distilled water. Each solution was analyzed in triplicate for the minerals Fe, Zn, Ca, Mg, Mn, Na and K using atomic absorption spectrophotometer (AAS- Bulk Scientific model AVG 211).

Statistical Analysis

The assays were carried out in triplicate (n= 3) and the results were expressed as mean values ± standard deviation (SD). Data were analyzed for variation using one-way analysis of variance (ANOVA) and the means separated by Duncan's multiple-range test and $p<0.05$ was regarded as level of significance.

RESULTS AND DISCUSSION

The nutritional and chemical properties of ginger leaf based herbal tea exposed to different pretreatments were examined in the present study. The results showed that steam blanched leaves had significantly higher protein, fat, fibre, ash, carbohydrate content and Ferric Reducing Antioxidant Power (FRAP) (Table 1) than the hot water blanched leaves.

Protein content was found to be highest in steam blanched herbal tea at 5.76 ± 0.126 % although this value was not significantly different from that of the air-dried herbal tea at 5.68 ± 0.001 %. Both steam-blanched and directly air-dried samples had increased protein content compared to the hot water blanched leaves. The level of protein present in steam balanced leaves and those dried directly were very high compared to the report of Akande *et al*. [20] when they analyzed the protein content in existing tea brands in Nigeria such as Top tea, Lipton, Green tea, Nescafe and lemon grass which had values ranging from 0.16 to 0.44 %. Teas are not primarily consumed for their protein content which implies that steam-blanched (F1) and air-dried (F2) herbal tea could contribute to daily required protein in man.

Moisture content in steam blanched leaves (6.67 ± 0.29 %) and hot water blanched ones (6.89 ± 0.20 %) were both significantly higher than those dried directly (5.13±0.15 %) (Table 1). The moisture contents fell within the range of values 5.60 – 7.50 % as reported for 5 brands of Tea (Camellia sinensis) [21]. During the process of steam blanching, cell membrane disruption occurs resulting in turgor loss and subsequent softening of tissue cells [17]. This leads to shrinkage and the resultant observed weight loss can be attributed to this phenomenon. Lower moisture content reduces the onset of microbial activities, fungal growth and redox reactions.

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Crude fiber content ranged between 2.50 ± 0.00 and 3.33 ± 0.29 % in the dried leaves. These were found to be lower than 5.94 % and 5.04 % as found in *Camellian sinensis* and *Camellia assamica* leaves reported by Pradhan and Dubey [22]. The fibre contents were well below the upper limit of ≤ 16.7 % specified for teas (ISO 3720-1997) [22] but not up to 4.37 % quoted as the lower limit by Aroyeun *et al*. [23]. Crude fibre intake promotes ease of bowel movement especially when constipated [21].

Crude fat content in the dried leaves was not significantly different at $p < 0.05$ and is comparable to crude fat content in *Dracaena manni* leaf (0.80 ± 0.25 %) and *Dracaena arborea* leaf (0.76 ± 0.32 %) which are herbal tea leaves commonly consumed in South Eastern Nigeria [24]. Fat content was within the range of 0.95-1.62 % recommended by Aroyeun *et al*. [23] for good quality tea.

Ash content, which is indicative of the quantity and quality of minerals present was found between 1.48 – 0.62 % for dried leaves. It has been proposed that for tea to maintain good quality during storage, initial ash content should not exceed 5.54 % [25], while the ISO standard minimum percentage ash content was quoted as 4 % [23].

The carbohydrate contents were higher than the values found in the leaves of *Dracaena manni* (67.08 ± 0.66 %) and Dracaena arborea (69.07 ± 0.53 %) [24]. Values were comparable to *Bupleurum falcatum* with 80.48 ± 0.02 % carbohydrate content [26]. High carbohydrate content indicates that the pretreated tea in this study can be a good energy source.

Phenol content of steam blanched leaves was higher than those that were hot water- blanched and those dried directly, but it was not significantly different from fresh leaves. Since phenols are antioxidants, it could be proposed that steam blanching helps to retain the therapeutic properties that are useful in ameliorating diseases caused by presence of free radicals in humans.

As for phenols, flavonoids content in steam blanched leaves (72.94±3.05 mg/100 g) was significantly higher than those dried directly (64.42±2.777 mg/100 g) and those that were hot water-blanched (68.01 ±2.15 mg/100 g) at $p<0.05$ (Table 2). Flavonoid content in steam-blanched leaves under this study was found to be higher than that reported for steam-blanched and unblanched *moringa* leaves ranging from 19.07±0.70 to 21.21±0.24 mg QE/100 g [15]. Flavonoids have been reported as being responsible for anti-allergic, anti-inflammatory, anti-viral, anti-carcinogenic properties observed during the use of any plant part [27].

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Heat treatments reduced the vitamin C contents significantly compared to the fresh leaves; however, steam-blanched leaves retained more of vitamin C content. Temperatures involved in the pretreatments led to breakdown and subsequent inactivation of some of the ascorbic acid, while some also could have been lost during rinsing [28]. Vitamin C content in leaves that were steam- blanched before drying was higher than that in steam- blanched *Moringa oleifera* leaves 44.80 ± 2.42 mg/100 g [15]. It was also found comparable to ascorbic acid content in *Corcorus spp* leaves having 89.94 mg/100 g and higher than 32.15 mg/100 g reported for *Vernonia amygdalina* [29].

The DPPH activity in steam blanched leaves (48.04±0.35 %) was significantly higher than leaves dried directly (46.08±1.07 %) and those that were hot water blanched (46.19±1.22 %). This signifies that steam-blanched herbal tea (F1) is a potentially better immune booster [30] than directly air-dried herbal tea (F2). This activity was found lower than those reported for leaves of *Physalis minima, Solanum nigrum, Withania somnifera, Kigelia* Africana with values ranging from 59.66 -77.33 % while it was comparable with *Datura inoxia* leaves having 50.33 % scavenging activity [31].

Ferric Reducing Antioxidant Power (FRAP) was significantly higher in directly air-dried herbal tea and steam-blanched herbal tea than hot water-blanched herbal tea (Table 2). It could be proposed that type of pretreatment was responsible for the observed change. Higher FRAP value signifies higher antioxidant capacity of steam blanched and directly air-dried herbal tea.

Saponin content in both steam-blanched and directly air-dried herbal tea were found comparable to that reported for leaves of *Ocimum canum* and *Mentha Xpiperita* which ranged from 2.9-3.8 mg/100 g [32] but were higher than 0.27 mg/100 g reported for Ficus capensis leaves [34]. Saponins are known to possess antimicrobial activities and therefore contribute to homeostasis in the body [34, 35].

Pretreatments in the present study contributed significantly to lowering the quantity of tannin in steam-blanched herbal tea while it was significantly increased in directly air-dried herbal tea. Tannin level in steam-blanched herbal tea was found comparable to that in green tea, black tea and red tea (18.90, 12.26 and 19.15 %, respectively) [36]. Tannins possess anti-cancerous, antimicrobial, anthelmintic, anti-viral and wound healing properties but under certain consumption conditions, cause reduced digestibility, antinutritional effect, cancer inducer and many other diseases [37]. The importance of tannins in promoting glucose absorption, thereby reducing the risk of diabetes has also been established [38].

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Phytate concentration in the steam-blanched and air-dried herbal teas was not significantly different but was significantly higher than in hot water-blanched herbal tea. Phytate in human diet limits the uptake of such minerals as Zn, Fe and Ca ions. It also forms a strong complex with some proteins at some pH, thereby preventing their proteolysis and hindering enzymatic activity [39].

Results of oxalate analysis showed a significant reduction in only the steam blanched leaves ($p<0.05$) as shown in Table 3. Values ranged between 0.56-0.61 mg/100 g and these were found lower than that of all 16 pretreated leaves with values ranging from 1.54 mg/100 g in *Cleome gynandra* leaves to 20.36 mg/100 g in *Amaranthus blitum* as reported by Wakhanu *et al*. [40]. Reducing oxalate concentration in human diets is very important due to the fact that it inhibits micronutrient absorption, blocks the kidney in form of accumulated stones and is a precursor for rheumatoid arthritis [41].

Results on mineral analysis show that steam blanched herbal tea had the highest concentrations of Na and K (Table 4), while highest concentrations of Fe, Ca, Mg and Mn was found in directly air-dried herbal tea. From the results, it could be proposed that pretreatment done in this study improved the concentration of some minerals present in the sample. Sodium and K ions are very important in the biological system. While Na ions regulate the electrolyte balance in the body, potassium ions help to maintain osmolarity of the cell. Sodium and K levels in both F1 and F2 were higher than those reported in different types of Chinese tea [42]. Potassium and sodium in black tea were 7.61 and 0.02 mg/100 ml, green tea was 9.36 and 0.49 mg/100 ml and white tea were 6.43 and 0.052 mg/100 ml. Calcium is the commonest mineral in the body and is responsible for fatty acids transport, which is important for the prevention of cardiovascular diseases. Magnesium conducts nerve impulses while Zn is important to bone formation alongside calcium. Iron is important for oxygen transport in the blood and can be seen in appreciable levels in steam-blanched and directly air-dried herbal tea (Table 4).

CONCLUSION

From the research output above, it can be proposed that steam blanching of ginger leaves before consumption in tea form, is highly beneficial in terms of nutrient and anti-nutrient properties followed by hot water blanching before drying, then direct drying that is, Steam blanching then drying > Hot water blanching then drying > Direct drying.

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Table 1: Proximate composition of pretreated ginger herbal teas

Samples	Protein (%)	Fat (%)	Fibre (%)	Moisture (%)	Ash (%)	CHO (%)
F1	5.76±0.13^{a}	0.93±0.05^{a}	2.50±0.00^{a}	6.67±0.29^{a}	1.48±0.03^{a}	82.66±0.36^{a}
F2	5.68±0.01^{a}	0.87±0.06^{a}	3.33±0.29^{b}	5.13±0.15^{b}	1.50±0.00^{a}	83.48±0.25^{a}
F3	4.10 ± 0.12^{b}	0.79± 0.04^{a}	3.18±0.16^{b}	6.89±0.20^{a}	0.62±0.01^{b}	64.32±0.23^{b}
F4	1.94±0.11	0.59±0.03	1.47±0.29	76.10±0.70	0.82±0.07	19.09±0.83

*Values are expressed as mean ± standard deviation. Values carrying the same letter within a column are not significantly different at p< 0.05
F1- Steam blanched herbal tea, F2- Air-dried herbal tea, F3-hot water blanched, F4- Fresh Ginger leaves

Table 2: Antioxidant properties of pretreated ginger herbal teas

Sample	Phenol (mg/100g)	Flavonoid (mg/100g)	Vit C (mg/100g)	DPPH (%)	FRAP (mg/100g)
F1	108.24±4.19^{a}	72.94±3.05^{a}	84.69±0.13^{a}	48.04±0.35^{a}	4.27±0.56^{a}
F2	77.94±5.55^{b}	64.42±2.77^{b}	82.52±2.42^{a}	46.08±1.07^{b}	4.89±0.54^{a}
F3	84.12± 3.32^{c}	68.01±2.15^{b}	68.90±1.82^{b}	46.19±1.22^{b}	3.21±0.37^{b}
F4	104.81±3.17	73.80±1.29	96.95±1.65	47.08±0.16	2.86±0.05

*Values are expressed as mean ± standard deviation. Values carrying the same letter within a column are not significantly different at p< 0.05
F1- Steam blanched herbal tea, F2- Directly air-dried herbal tea, F3- Hot water blanched herbal tea, F4-Fresh leaves

Table 3: Phytochemical properties of pretreated ginger herbal teas

Samples	Saponin (mg/100g)	Tannin (mg/100g)	Phytate (mg/100g)	Oxalate (mg/100g)
F1	3.65±0.05^{b}	12.26±0.19^{a}	56.80±2.05^{a}	0.56±0.03^{a}
F2	3.64±0.02^{b}	46.58±1.21^{b}	54.79±1.20^{a}	0.61±0.02^{b}
F3	3.24±0.01^{a}	15.80±1.31^{c}	42.01±1.72^{b}	0.61±0.01^{b}
F4	3.40±0.16	37.97±0.24	61.21±0.84	0.66±0.01

*Values are expressed as mean ± standard deviation. Values carrying the same letter within a column are not significantly different at p< 0.05. F1- Steam blanched herbal tea, F2- Directly air-dried herbal tea, F3- Hot water blanched herbal tea, F4-Fresh leaves

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Table 4: Mineral composition of pretreated ginger herbal teas

Sample	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Mn (mg/100g)	Na (mg/100g)	K (mg/100g)
F1	1.75±0.06^{a}	0.11±0.01^{a}	15.83±0.18^{a}	11.84±0.19^{a}	1.93±0.10^{a}	8.89±0.09^{a}	502.00±3.50^{b}
F2	2.29±0.15^{b}	0.08±0.01^{a}	20.53±0.23^{b}	11.92±0.22^{a}	2.46±0.03^{b}	8.79±0.03^{a}	490.67±4.55^{a}
F3	1.22±0.08^{a}	0.10+0.01^{a}	15.40±0.26^{a}	10.96±0.18^{a}	1.88±0.01^{a}	8.10±0.02^{a}	430.99±2.33^{c}
F4	0.98±0.13	0.52±0.12	13.24±0.62	5.92±0.83	1.28±0.14	5.57±0.34	298.37±1.71

*Values are expressed as mean ± standard deviation. Values carrying the same letter within a column are not significantly different at p< 0.05. F1- Steam blanched herbal tea, F2- Directly air-dried herbal tea, F3- Hot water blanched herbal tea, F4-Fresh leaves

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