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Development and comparative evaluation of green and black tisanes using scent leaves (*Chromolaena odorata*)

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Abstract

The development of tisanes as nutraceuticals for health therapy is needful. *Chromolaena odorota* as potential tisane was studied. Green (GTS) and black (BTS) tisanes were developed and analyzed in comparison with commercial green (GTE) and black tea (BTE) for their physico-chemical properties, phyto-nutrient contents, antioxidant potentials and sensory qualities. The chemical properties of the dried samples showed that GTS had the highest crude fibre (11.35%) and ash (3.19%) while GTE had the highest protein (18.42%) and lipid (2.32%). The teas were more acidic (4.08-5.81) than tisanes (5.35-5.81). GTS had the highest total solids (4.97%) and lowest specific gravity (1.01). The Sodium in the tisanes was low (3.94-6.81 mg/100 mL) while the potassium was high (37.06-40.02 mg/100 mL). Vitamin E in GTS (0.67 mg/mL) and GTE (0.45 mg/mL) were higher than in BTS (0.43 mg/mL) and BTE (0.29 mg/mL). Vitamin C (8.02-14.52 mg/mL) was more than the B-vitamins (0.21-5.36 mg/mL) in all samples. Cyanogenic-glycoside was low (0.46-1.06 mg/100 mL) in the samples. GTS (26.02 mg GAE/mL) and BTS (22.96 mg GAE/mL) contained more total phenols. The same trend was observed for the total flavonoids. The green samples GTS (26.12 mmol TE/mL) and GTE (24.25 mmol TE/mL) exhibited the highest antioxidant activities. The green tisane GTE (6.24) was more preferred to black tisane BTS (5.84) and branded green tea GTE (5.96) in terms of overall acceptance. The results demonstrated the use of *Chromolaena odorota* as tisane with enormous therapeutic potentials.

1. Introduction

Tea is an aqueous infusion of dried leaves of the plant *Camellia sinensis* (Wu and Wei, 2002). It is considered a pleasant, economical and socially accepted health beverage, due to its refreshing and mild stimulating effects (Harbowy *et al.,* 1997; Abdel-Raheim *et al*., 2009). It is consumed as health-drink or extracts because of the systemic health effects. Unfortunately, the medicinal properties of tea are often overlooked. Tea is reported to contain thousands of bioactive components most of which are polyphenols (Joubert *et al*., 2008; Ndife, 2016). Polyphenols play a key role in the prevention and treatment of many diseases (Chacko *et al*., 2010; Harini *et al*., 2014).

Tea is also a rich dietary source of other antioxidant nutrients such as carotenoids, tocopherols, ascorbic acids and phytochemicals (Wu and Wei, 2002; Chan *et al*., 2011). Numerous studies have demonstrated that aqueous extracts of black and green tea possess antimutagenic, anti-inflammatory, hypocholesterolemic, antibacterial, antidiabetic, anti-tumour, anti-UV-induced oxidative damage, anti-carcinogenic properties (Wu and Wei, 2002; Chacko *et al*., 2010).

In recent times, Tisane, a generic term for tea made from herbs which serve as a beverage for their physical or medicinal effects is gaining increasing popularity among health-conscious consumers because of their fragrance, antioxidant properties and therapeutic applications (Gill, 1992; Oludare *et al*., 2000). Tisane is made from the infusion or decoction of herbs, spices or any other plant material in hot water and usually does not contain caffeine (Triratana *et al.,* 1991). Tisanes are categorized by what part of the plant they come from: Leaf tisanes (mint, neem, cocoa, lemon grass); Flower tisanes (rose, chamomile, hibiscus and lavender); Bark tisanes (cinnamon, slippery elm and black cherry bark); Root tisanes (ginger, *echinacea* and chicory) and Fruit tisane from citrus peel, raspberry, blueberry, peach (Biswal *et al.,* 1997; Apichart *et al.,* 2004).

Chromolaena odorota, is an African medicinal plant which is used in Nigerian traditional medicinal practices to treat various ailments of microbial origin (Apichart *et*

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al., 2004; Ugwoke *et al*., 2017). It has been observed to possess some properties which can attack cancer cells resulting from an internal wound in the human body (Akinmoladun *et al*., 2007; Odutayo *et al*., 2017). *Chromonlaena odorata* has been found to be effective in Ayurveda medicine (Biswal *et al.,* 1997; Ugwoke *et al*., 2017) as a potent therapeutic agent with little or no adverse effect (Jumaat *et al.,* 2017). Current studies have revealed its hypolipidemic and hypoglycemic abilities (Idoko *et al*., 2018), anti-inflammatory, anti-pyretic, analgesic, antimicrobial, and many other relevant medicinal properties (Biswal *et al.,* 1997; Apichart *et al*., 2004; Akinmoladun *et al*., 2007; Odutayo *et al*., 2017).

There are prospects for the commercial utilization of *Chromonaela odorata* in view of its useful phytonutrients and widespread nature. It can be processed as a tisane, in order to make this health-packed leaf available as herbal tea so as to take advantage of the medicinal properties. This study, therefore, investigated the potentials of tisane produced from *Chromonaela odorata* in comparison to conventional commercial green and black teas.

2. Materials and methods

2.1 Sources of raw materials

Chromoleana odorata leaves used for this study were obtained within the Michael Okpara University of Agriculture, Umudike and the species were identified in the Department of Botany of same University. Reagents and equipment used for analysis were from the laboratory of the Department of Biochemistry, National Root Crops Research Institute Umudike, Abia State.

2.2. Production of the tisane powder and extracts

Fresh *Chromoleana odorata* leaves collected were washed to reduce microbial load and remove field debris. The leaves were divided into two sets. One set of leaves was used in the production of green tisane while the other set was used for the production of black tisane. In black tisane (BTS) production, the leaves were allowed to wither and ferment in the shade for 6 hrs, while for the green tisane (GTS) the leaves were steam-blanched for 3 mins; the water was drained off the leaves and allowed to cool at the room temperature. Both the GTS and BTS leaves were manually roll-pressed with wooden roller until the leaves were sufficiently flattened in order to rupture and release the leave components from interstitial cells. This was followed by oven drying the leaves at 50^{o}C for 6 hrs. The dried leaves were ground into very small particles and sieved. The process of grinding and sieving was repeated until uniform powdered particles were obtained. The powdered leaves were weighed into tea-bags before sealing. The packaged green and black tisanes as well the commercial green (GTE) and black (BTE) teas (50 g each) were infused in 100mL of hot water (80^{o}C) for 10 mins, cooled to room temperature and the extracts were bottled and kept in refrigerator pending their analyses.

2.3 Physico-chemical properties analysis

The physical properties: specific gravity and pH; chemical properties which include total titratable acidity (TTA) and total sugar and the proximate composition of the samples were determined as described by Onwuka (2018). The carbohydrate and energy values were obtained by recommended mathematical procedures.

2.4 Mineral analysis

The mineral elements of the samples were determined according to the method described by AOAC (2005). Standard curves of the respective metals were used to quantify the elements using Atomic Absorption Spectrophotometer (AAS).

2.5 Vitamin analysis

The vitamin contents were determined using high performance liquid chromatography (HPLC) fitted with a UV-visible detector (Nielsen, 2003).

2.6 Phytochemical analysis.

The phytochemical components which included total tannins, total saponins, total alkaloids, total steroids and cyanogenic-glycoside were determined by methods as described by Onwuka (2018) with some modifications.

2.7 Antioxidant evaluation

The total polyphenols of the extracts were determined using the Folin-ciocalteu assay and aluminum chloride was used for total flavonoids determination (Laroze *et al*., 2006). The ability of the extracts to scavenge ABTS (2,2'-azino-di-[3-ethylbenzthiazoline sulphonate) radicals and the Ferric Reducing Antioxidant Power (FRAP) were determined according to the method described by Thaipong *et al*. (2006).

2.8 Sensory analysis

The sensory properties of the samples were evaluated by panelists drawn from the staff and students of the university, as described by Iwe (2010). The sensory attributes of colour, taste, aroma, texture and general acceptability, were evaluated using a 9-point hedonic Scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely).

2.9 Statistical analysis

The experimental design was completely randomized. All determinations were done in triplicates and their mean values were recorded with standard deviations. The data obtained from the various analyses were subjected to analysis of variance using the statistical package for social sciences (SPSS), version 16.0 for windows. One-way analysis of variance (ANOVA) was used for comparison of the means. Differences between means were considered to be significant at $p<0.05$ using the Duncan multiple range test.

3. Results and discussion

3.1 Proximate composition of the dried samples

The result of the proximate analysis of dried *Chromoleana odorata* leaves and tea samples is presented in Table 1. There was a significant difference ($p<0.05$) in the proximate composition of the tea samples. Green tisane (GTS) had the highest moisture (12.83%), crude fibre (11.35%) and ash (3.19%) contents while green tea (GTE) had the highest protein (18.42%) and ether extract (2.32%). These values were higher in moisture (5.65%) and carbohydrate (1.10%), but lower in protein (24.08%) fiber (50.26%) and ash (10.98%) reported by Nwinuka *et al.* (2009) for dried *Chromoleana odorata* leaves. The lipid content (2.32%) of green tea could make it susceptible to rancidity. The 31.9% ash content of green tisane showed that it could contain a reasonable amount of minerals. The moisture content of the samples is an index of their water activity (Onwuka, 2018) and is used as a measure of stability and susceptibility to microbial contamination (Nwinuka *et al.*, 2009). This implies that GTS may have a short shelf-life due to its high moisture content. Dehydration will also help to increase the relative concentration of the other nutrients' components (Okafor and Ogbobe, 2015).

3.2 Physico-chemical properties

The result of physico-chemical properties of tisane from *Chromoleana odorata* and tea are shown in Table 2. There was a significant difference ($p<0.05$) in the properties except in specific gravity. The pH is a measure of the acidity or alkalinity of foods (Onwuka, 2018). The teas (TE) were more acidic (4.08-5.81) than the tisane (TS) products (5.35-5.81). BTE had the least pH (4.08) while GTS had the highest pH (5.81) which signifies that *Chromoleana odorata* leaves had higher pH than *Carmallia sinensis.* The low pH of the tisane samples suggests better stability while in storage as pH has been reported to be one of the important quality characteristics that describe the stability of bioactive compounds in tea products (Harbowy *et al.,* 1997; Drouzas *et al.,* 1999). The total titratable acidity (TTA) measures the ionic strength of a solution which in turn determines the rate of chemical reaction. BTE had the highest TTA (2.41%) while GTS had the least (0.41%). There was a significant difference ($p<0.05$) in the TTA among the samples. The total titratable acidity revealed low values which corroborate with the measured pH. Harini *et al.* (2014) reported a pH of 6.31 for water extracts of *Chromolaena odarata* leaves.

The total sugar content of the tisane and tea samples were also significantly different ($p<0.05$) from each other. GTS recorded higher total sugar (4.97%) than GTE (3.95%). Among the tea samples, BTS had higher total sugars (4.81%) than BTE (3.71%) which indicates that the *Chromoleana odorata* contained more sugars than the *Camellia sinensis* leaves. Free sugar or added sugars should not be more than 5% of the energy a person should get from food and drink each day (Wardlaw, 2004), which implies that the tisanes are good for consumption. The specific gravity ranged from 1.01 to 1.71 in the samples. There was no significant difference ($p>0.05$) in the specific gravity of the samples except in BTE (1.71). This implies that there were little or no residues in the tea and tisane extracts.

3.3 Mineral content

The mineral composition of the Tisane and tea extracts is shown in Table 3. The result showed a significant difference ($p<0.05$) in most of the metals among the products. GTE had the highest Ca (2.47 mg/100 mL) followed by GTS (2.01 mg/100 mL). Ca is associated with reduced risk of osteoporosis, hypertension and pre-menstrual syndromes. It also plays an important role in blood clotting and muscles (Wardlaw, 2004). This could be the reason for which *Chromolaena odorata* leaves are excellent in stopping bleeding topically.

The low Na content of the teas (3.93-4.83 mg/100 mL) and tisanes (3.94-6.81 mg/100 mL) makes it suitable in the treatment of hypertension and renal diseases according to Emebu and Anijika (2011). The potassium levels in the tisanes (37.06-40.02 mg/100 mL) and teas (44.01-44.28 mg/100 mL) were higher than those of sodium. The beneficial effect of low sodium in the control of arterial hypertension requires an increase in potassium intake (Wardlaw, 2004). This would mean that the consumption of tisanes and teas could prevent high blood pressure (Adepoju and Oyewole, 2008).

The Mg level of the samples was in the range of 5.37 to 6.92 mg/100 mL. The amount obtained in this study would help contribute to the dietary intake. Mg is required for the human body's muscular contractions

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Table 1. Proximate composition of dried tea

Samples	MC (%)	CP (%)	CF (%)	EE (%)	ASH (%)	CHO (%)	EV (Kcal)
BTS	10.96±0.04^{b}	13.81±0.01^{d}	10.19±0.03^{b}	1.36±0.01^{d}	3.03±0.01^{b}	60.66±0.01^{b}	310.10±0.04^{c}
GTS	12.83±0.02^{a}	17.12±0.01^{b}	11.35±0.02^{a}	1.88±0.01^{c}	3.19 ± 0.00^{a}	53.66±0.01^{d}	300.02±0.04^{d}
BTE	9.49±0.03^{c}	15.28±0.02^{c}	7.53±0.01^{d}	2.10±0.00^{b}	2.95 ± 0.00^{d}	62.73±0.01^{a}	330.94±0.12^{a}
GTE	9.09±0.02^{d}	18.42±0.01^{a}	8.25±0.01^{c}	2.32±0.02^{a}	2.95 ± 0.01^{c}	58.98±0.01^{c}	330.41±0.11^{b}

Values are mean ± standard deviation. Means in the same column having different superscripts are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; MC-moisture content; CP-Crude Protein; CF-Crude Fibre; EE-Ether Extract; ASH-Ash Content; CHO-Carbohydrate; EV-Energy Value.

Table 2. Physico-chemical properties

Samples	TTA (%)	pH	TS (%)	SG
BTS	0.70 ± 0.00^{c}	5.35 ± 0.01^{b}	4.81 ± 0.01^{b}	1.05 ± 0.00^{a}
GTS	0.41 ± 0.01^{d}	5.81 ± 0.01^{a}	4.97 ± 0.01^{a}	1.01 ± 0.00^{a}
BTE	2.41 ± 0.01^{a}	4.08 ± 0.01^{d}	3.71 ± 0.01^{d}	1.71 ± 0.01^{d}
GTE	1.64 ± 0.01^{b}	4.14 ± 0.02^{c}	3.95 ± 0.01^{c}	1.03 ± 0.00^{a}

Values are mean ± standard deviation; Means in the same column having different superscripts are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; TTA-Total Titrable Acidity; TS-Total Sugar; SG-Specific Gravity.

Table 3. Mineral composition (mg/100 mL)

Samples	Ca	Na	Mg	P	K	Fe	Zn
BTS	1.87±0.02^{d}	6.81±0.01^{c}	5.45±0.02^{c}	21.02±0.02^{d}	37.06±0.03^{d}	3.53±0.03^{c}	0.36±0.01^{c}
GTS	2.01±0.02^{c}	3.94±0.04^{b}	5.37±0.02^{d}	21.80±0.02^{c}	40.02±0.02^{c}	3.40±0.02^{d}	0.38±0.00^{a}
BTE	2.15±0.03^{b}	3.98±0.01^{b}	6.82±0.03^{b}	30.15±0.01^{b}	44.01±0.01^{b}	3.92±0.01^{a}	0.37±0.03^{a}
GTE	2.47±0.03^{a}	4.83±0.03^{a}	6.92±0.02^{a}	30.64±0.01^{a}	44.28±0.01^{a}	3.81±0.02^{b}	0.34±0.01^{b}

Values are mean ± standard deviation; Means in the same column having different superscript are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; Ca-Calcium, Na-Sodium, Mg-Magnesium, P-Phosphorus, K-Potassium, Fe-Iron, Zn-Zinc.

Table 4. Vitamin composition (%)

Sample	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin B_3	Vitamin C	Vitamin E
BTS	9.06±0.02^{c}	0.23±0.01^{b}	4.26±0.04^{a}	0.31±0.01^{a}	8.02±0.00^{d}	0.43±0.02^{b}
GTS	8.42±0.01^{d}	0.63±0.01^{d}	5.36±0.04^{b}	0.38±0.01^{b}	8.92±0.01^{c}	0.67±0.02^{a}
BTE	12.02±0.01^{a}	0.51±0.01^{a}	3.06±0.01^{c}	0.16±0.01^{c}	12.36±0.02^{b}	0.29±0.01^{c}
GTE	11.47±0.01^{b}	0.76±0.01^{c}	3.21±0.02^{d}	0.21±0.00^{d}	14.52±0.01^{a}	0.45±0.01^{b}

Values are mean ± standard deviation; Means in the same column having different superscript are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; Vitamin A-Retinol, Vitamin B1-Thiamin, Vitamin B2-Riboflavin, Vitamin B3-Niacin, Vitamin C-Ascorbic acid, Vitamin E-Tocopherol

Table 5. Phytochemical properties (mg/100 mL)

Samples	TAN	SAP	ALK	C.GLY	STE
BTS	1.21±0.01^{c}	3.13±0.04^{c}	0.92±0.02^{a}	0.71±0.01^{b}	2.08±0.04^{b}
GTS	0.76±0.04^{d}	2.26±0.05^{d}	0.61±0.02^{b}	1.06±0.05^{a}	1.75±0.02^{c}
BTE	1.47±0.02^{a}	3.61±0.01^{a}	0.46±0.01^{c}	0.46±0.04^{d}	2.21±0.03^{a}
GTE	1.32±0.02^{b}	3.23±0.03^{b}	0.34±0.01^{d}	0.62±0.01^{c}	2.07±0.02^{b}

Values are mean ± standard deviation. Means in the same column having different superscripts are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; TAN-Tannin; SAP-Saponin; Alk-Alkaloid; C.GLY-Cyanogenicglycoside; STE-Steroid

Table 6. Antioxidant potential of the tea samples

Samples	TP (mg GAE/mL)	TF (mg QE/mL)	FRAP (μmol/Fe^{2+}/L)	ABTS (mmol TE/mL)
BTS	22.96±0.02^{b}	8.61±0.00^{a}	210.12±0.02^{d}	23.84±0.04^{c}
GTS	26.02±0.02^{a}	11.12±0.01^{c}	279.83±0.03^{c}	26.12±0.02^{a}
BTE	10.61±0.01^{d}	9.83±0.02^{b}	297.62±0.02^{b}	21.53±0.00^{d}
GTE	15.04±0.03^{c}	13.05±0.01^{d}	325.41±0.02^{a}	24.25±0.00^{b}

Values are mean ±standard deviation; Means in the same column having different superscript are significantly different ($p<0.05$). BTS-Black Tisane; GTS-Green Tisane; BTE-Black Tea; GTE-Green Tea; TP-Total Phenol, TF-Total Flavonoid, FRAP-Ferric Reducing Antioxidant Power; ABTS-Azino Benz Thiazoline Sulphonate

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(Wardlaw, 2004). The phosphorus content of the tisanes (21.02-21.80 mg/100 mL) was higher in values than for teas (30.15-30.64 mg/100 mL). Phosphorus is needed by the body to repair tissue cells and to build strong bones and teeth (Emebu and Anijika, 2011). In comparison, Czernicka *et al*. (2017) reported low mineral values for Ca (0.13- 0.40 mg/100 mL), P (1.12-1.18 mg/100 mL) and Mg (0.45- 0.72 mg/100 mL) in black and green tea infusions.

Fe and Zn are essential trace elements required for optimal human growth, development and maintenance of immune function (Wardlaw, 2004). The level of iron (3.40-3.53 mg/100 mL) and zinc (0.36-0.38 mg/100 mL) in the tisanes showed tisane as a better source of Fe when compared with tea. Nwinuka *et al.* (2009) reported that the leaves of *Chromolaena odorota* were rich in mineral elements such as Ca, Na, K, Fe, Mn, Zn, Cu, P, and Mg. Minerals and vitamins synergize with phytochemicals to confer medicinal properties on plant foods (Akinmoladun *et al*., 2007)

3.4 Vitamin content

Table 4 shows the vitamin content of the samples. GTS had the highest vitamin E (0.67 mg/mL). The green samples GTS (0.67 mg/mL) and GTE (0.45 mg/mL) were higher than the black samples BTS (0.43 mg/mL) and BTE (0.29 mg/mL). The result obtained in this study showed significant difference ($p< 0.05$) in vitamins in all samples. The higher value of vitamin E in GTS and GTE could be due to the high lipid content of the dried leaves (Adepoju and Oyewole, 2008; Nwinuka *et al*., 2009). Vitamin E has been reported to be fat soluble antioxidant, which protects low density lipoprotein against peroxidation (Yokozawa *et al.,* 2002). However, heat treated BTS (9.06 mg/mL) and BTE (12.02 mg/mL) had the highest Vitamin A. Okafor and Ogbobe (2015) also reported higher Vitamin A content in black *moringa* tea (20.37 β-carotene eq/mg) when compared to green *moringa* tea (8.12 β-carotene eq/mg). Vitamin A has been reported to be heat stable (Okwu and Ndu, 2006; Ndife, 2016). Vitamin A plays critical roles in vision, bone growth and reproduction (Wardlaw, 2004; Okwu and Ndu, 2006).

Vitamin B and C are water soluble vitamins which are heat labile (Onwuka, 2014). Vitamin C (8.02-14.52 mg/mL) was more in all the samples than the B-vitamins (0.21-5.36 mg/mL). This showed that the fresh leaves had more of the vitamin C than B-vitamins. Among the B-vitamins, B_2 (3.06-5.36 mg/mL) was the highest in the samples. GTS and GTE had higher vitamins C (8.92) and B_1 (0.76) than BTS (8.02) and BTE (12.36) the same trend was recorded for vitamins B_2 and B_3. These variations could be due to the processing conditions which required fermentation and heating (Okafor and Ogbobe, 2015). Vitamins C and E contribute to total antioxidant defense system (Wardlaw, 2004; Abdel-Raheim *et al.,* 2009).

3.5 Phyto-chemical content

The phytochemical constituents of tisane and tea samples are presented in Table 5. The concentration of the phytochemical compounds was significantly different ($p<0.05$) among the samples. BTS (2.08 mg/100 mL) and BTE (2.21 mg/100 mL) had higher sterol content than GTS (1.75 mg/100 mL) and GTE (2.07 mg/100 mL). Sterols are fat-soluble bioactive which act as plant hormones (Ndife, 2016). Phytosterols have proven total serum and LDL cholesterol lowering efficacy and also protect against colon, breast and prostate cancers (Wardlaw, 2004; Ndife, 2016).

The alkaloid in the tisanes (0.71-1.47 mg/100mL) was higher when compared with that in teas (0.34-0.46 mg/100mL). Alkaloids are capable of reducing migraines associated with hypertension and also help in the management of cold and chronic catarrh (Gill, 1992). The total tannin in tisanes (0.76-1.32 mg/100 mL) was comparable to that in teas (1.21-1.47 mg/100 mL). Tannin has antimicrobial property (Okwu and Ndu, 2006; Ugwoke *et al*., 2017). Omokhua *et al.* (2017) also affirmed that tannins are involved in the treatment of inflamed or ulcerated tissues. Tisanes with high tannin content are astringents and are used for the treatment of intestinal disorders and inflamed or ulcerated tissues (Akinmoladun *et al*., 2007; Idoko *et al.,* 2018). The presence of tannin in the tisanes supports the traditional medicinal use of tisane leaves in the treatment of different ailments (Jumaat *et al*., 2017).

Cyanogenic-glycoside (0.46-1.06 mg/100 mL) was low when compared with the total saponins (2.26-3.61 mg/100 mL) in the samples. Saponins are active antifungal agents, anti-carcinogenic and immune modulators (Odutayo *et al*., 2017; Omokhua *et al*., 2017). The phytochemical values were lower than values reported by Nwinuka *et al*. (2009) for alkaloids (18.38%), saponins (14.90%), cyanogenic-glycosides (3.27%) and tannins (0.14%) in dried *Chromolaena odorata* leaves.

Several studies have reported that *Chromolaena odorata* leaves contain several useful phytochemicals which are responsible for the flavors, colors and defense system of plants (Akinmoladun *et al*., 2007; Odutayo *et al*., 2017; Omokhua *et al*., 2017) hence their bioactive functionality. The anti-nutrient cyanogenic-glycoside concentration can be eliminated or reduced to tolerable level through processing methods like steaming,

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oxidation and fermentation (Ndife, 2016; Onwuka, 2018).

3.6 Antioxidant potential and activity

The antioxidant potential and activity of tisane and tea samples are shown in Table 6. The total phenol (TP) and total flavonoid (TF) content ranged from 10.61 to 22.96 mg GAE/mL and 8.61 to 13.05 mg QE/mL respectively. BTS (22.96 mg GAE/mL) and GTS (22.02 mg GAE/mL) had more TP than BTE (10.61 mg GAE/mL) and GTE (15.04 mg GAE/mL). However, the green tisane (GTS) and tea (GTE) had more TP than black tisane (BTS) and tea (BTE). The TP values were higher than 0.01 mg/g GAE reported by Akinmadun *et al.* (2007). The flavonoid content was higher in GTE (13.05 mg QE/mL) and GTS (11.12 mg QE/mL) than BTE (9.83 mg QE/mL) and BTS (8.61 mg QE/mL) probably because of fermentation and heat used during production (Ndife, 2016). There were significant differences in the TP and TF values of the samples ($p<0.05$). Several researchers have corroborated the in-vitro and in-vivo antioxidant activities of polyphenols and flavonoids, resulting in sparing effect on α-tocopherol and β-carotene (Brunetti *et al.,* 2013; Banjarnahor and Artanti, 2014; Omokhua *et al*., 2017). This supports the use of *Chromolaena odorota* for treatment of various diseases (Seeram *et al*., 2006; Agati *et al*., 2012).

Ferric Reducing Antioxidant Power (FRAP) assay measures the reducing ability of antioxidants against the oxidative effect of reactive oxygen species. The FRAP values of tisane samples (210.12-279.83 μmol/Fe^{2+}/L) were comparable to tea (297.62 - 325.41 μmol/Fe^{2+}/L), however the values were significantly different ($p< 0.05$). The high FRAP values signified that the products have the ability to scavenge free radicals (Akinmadun *et al.*, 2007).

The ABTS result showed the IC_{50} values of the tisane and tea samples. The green samples GTS (26.12 mmol TE/mL) and GTE (24.25 mmol TE/mL) exhibited higher antioxidant activities than BTS (23.84 mmol TE/mL) and BTE (21.53 mmol TE/mL). This corresponds with previous studies that green tea has high antioxidant activity than black tea (Ndife, 2016). The hypoglycemic and hypolipidemic activities of *Chromolaena odorata* extracts administered to rats was reported by Idoko *et al.* (2018) to be due to its phytochemical and antioxidants content. The result of a particular antioxidant assay depends on the chemistry of the assay and the nature and combination of bioactive principles in the material under investigation (Seeram *et al*., 2006; Akinmoladun *et al.,* 2007; Ndife, 2016).

3.7 Sensory evaluation

The result of the sensory evaluation of tisane and tea samples is presented in Table 7. This study revealed that black tea (BTE) had the highest mean score (7.08-7.60) in all the sensory parameters followed by green tisane (GTS). The low taste score for BTS (5.28) could be attributed to the fermentation process during its production. Apparently, it was not liked by the panelist. The same trend was observed in the aroma score for BTS (5.56). GTS had the lowest score (5.72) for appearance, followed by GTE (5.80). This was because the panelists were not favorable to the green colors; they thought the samples were raw in nature. The difference in sensory attributes ($p<0.05$), could be as a result of different composition of the raw materials and processing methods used. However, the green tisane (GTS) was generally more acceptable (6.24) next to the branded black tea BTE (7.60) and in preference to the branded green tea GTE (5.96) and back tisane BTS (5.84). This implies that appropriate methods of producing green and black tea were followed.

4. Conclusion

The results demonstrated the use of scent leaf (*Chromolaena odorota)* as a potential tisane. The green and black tisanes were comparable to branded teas in their physico-chemical properties, phyto-nutrient contents and antioxidant potentials. The concentration of cyanogenic glucosides in the tisanes was not high enough to cause toxicity. The green tisane was more preferred to black tisane and branded green tea in terms of their sensory acceptance.

More contributions are required for effective product development which will include sugars, fatty acids and amino acid profiling, toxicity tests to allay consumers' fears and the modification and optimization of the production process that will give high quality tisanes.

Table 7. Sensory evaluation of the tea samples

Samples	Taste	Aroma	Appearance	Acceptability
BTS	5.28 ± 2.05^{c}	5.56 ± 1.71^{b}	6.60 ± 1.22^{a}	5.84 ± 1.43^{b}
GTS	6.32 ± 1.25^{b}	6.00 ± 1.32^{b}	5.72 ± 1.02^{b}	6.24 ± 1.05^{b}
BTE	7.56 ± 0.96^{a}	7.44 ± 1.08^{a}	7.08 ± 1.32^{a}	7.60 ± 0.87^{a}
GTE	5.64 ± 1.75^{bc}	5.56 ± 1.47^{b}	5.80 ± 1.32^{b}	5.96 ± 1.54^{b}

Values are mean ±standard deviation of duplicate determinations. Means in the same column having different superscript are significantly different ($p<0.05$)

Conflict of Interest

We hereby declare no conflict of interest whatsoever.

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