Production and Evaluation of Herbal Tea Blends from Zobo (*Hibiscus sabdariffa*) and Jacobinia (*Justicia carnea*) Fortified with Ginger (*Zingiber officinale*)

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Abstract
This study involved the production and evaluation of herbal tea blends from powdered Zobo leaf (Hibiscus sabdariffa) and Jacobinia (Justicia carnea) leaf fortified with Ginger (Zingiber offinalle). Four blends were formulated using 100% Zobo as control. Other blends were 90:10 (Zobo and Ginger), 70:20:10 (Zobo leaf, Jacobinia leaf and Ginger), 60:30:10 (Zobo leaf, Jacobinia leaf and Ginger) and 50:40:10 (Zobo leaf, Jacobinia leaf and Ginger). The proximate composition, phytochemicals, minerals, vitamins, antioxidants and sensory properties were determined using standard methods. The proximate compositions ranged from 2.26% to 3.74%, 3.27% to 6.33%, 2.21% to 3.92%, 4.08% to 5.73%, and 7.76% to 9.61% for moisture, protein, lipid, ash, fibre and carbohydrate respectively. The phytochemical content ranged from 2.34 mg/100g to 3.86 mg/100g, 3.59 to 6.75 mg/100g, 5.17 to 10.25 mg/100g and 0.14 to 0.56 mg/100g for tannin, phytate, oxalate and saponin respectively. The mineral content ranged from 9.81 to 50.70 mg/100g, 4.35 to 33.54 mg/100g, 8.26 to 15.86 mg/100g and 6.17 to 34.7 mg/100g for calcium, magnesium, potassium and phosphorus respectively. The vitamin content ranged from 3.82 to 5.16 mg/100g and 55.10 to 72.53 mg/100g for vitamin A and B respectively. Panelists scored sample B higher than other samples in appearance (7.50) and taste (6.67) while sample A was scored higher in overall acceptability (7.33). The total phenolic content ranged from 1.176 to 20.991 mgGAE/g. Total flavonoid ranged from 71.5 to 85.5 mg/GAE/g. The DPPH scavenging activity at IC50 ranged from 40 to 100µg/ml greater than the standard ascorbic acid of 30µg/ml. The Reducing power assay ranged from 60µg/ml to >100µg/ml different from the standard ascorbic acid of 30µg/ml. In conclusion, Zobo leaf and Jacobinia leaf fortified with ginger is an effective means of improving the nutrients and health benefits of the herbal tea.

INTRODUCTION

Tea is a beverage consumed worldwide, either hot or cold depending on the consumer's preference. It is generally accepted that next to water, tea is the most consumed beverage in the world, (Bansode, 2015) and tea is majorly from the leaves of *Camellia sinensis* plant. (Namita *et al*., 2012) Recently, there is renewed interest in herbal teas which are considered to be caffeine free. Herbal tea is another important type of tea made from different raw materials such as spices, herbs, dried calyces, and dried fruit. (Joseph and Adogbo, 2015). These "herbal teas" contain a multitude of substances and could play an important role in supplying nutrients and chemicals to compensate for poor diets (Nibir *et al*., 2017).

Roselle (*Hibiscus sabdariffa*) tea is an example of herbal tea. Zobo leaves also known as Roselle leaves are the sepals of the hibiscus plant *Hibiscus sabdariffa* (Da-Costa-Rocha *et al*., 2014). The hibiscus plant is a blooming shrub that is indigenous to tropical regions of Africa and Asia and is a member of the Malvaceae family (Nwaiwu *et al*., 2020). Roselle leaves are commonly used in traditional medicine and culinary practices in many countries, including Nigeria, Mexico, and Thailand (Akujobi *et al*., 2019). They are known for their distinct flavor and are often used to make tea or infusions. Roselle leaves have a tart, tangy taste and are often compared to cranberries in terms of flavor (Ojulari *et al*., 2019). They are a rich source of antioxidants, flavonoids, and phenolic compounds, which are believed to contribute to their potential health benefits (Ojulari *et al*., 2019). They also contain a range of nutrients, including vitamin C, iron, and calcium. Additionally, Roselle leaves are low in calories and high in dietary fiber, making them a nutritious addition to any diet (Edo *et al*., 2023b).
Jacobinia (*Justicia carnea*) is a flowering plant, widely distributed in various parts of Africa. (Chimaraoke *et al*., 2017). In Nigeria, the shrubs of *Justicia carnea* are grown around homes and in some cases are used for fencing. In the local parlance, *Justicia carnea* is called "hospital too far" in some parts of Nigeria. The plant has been reported to also possess anti-inflammatory, anti-allergic, anti-tumoral, anti-viral and analgesic activities. (Radhika *et al*., 2013). It has also been reported to be rich in both macronutrients and trace elements of which calcium and iron are in high quantity (Faiza *et al*., 2013). The low levels of antinutritional factors such as phytate, trypsin inhibitor, oxalate, hydrogen cyanide, and hemagglutinin in the extract of *J. carnea* leaves indicate that they may not impair nutrient availability and digestibility (Orjiakor *et al*, 2019). Most of the medicinal properties exhibited by the plant extracts are associated with their bioactive constituents mainly phenols and flavonoids (Uroko *et al*., 2017). Onyeabo *et al*., (2017) reported a survey among the Igbo local populace in Nigeria which revealed that the plant is locally called "ogwu obara" meaning blood tonic. The deep purple coloured juice from the leaves of this plant is extracted either by soaking or boiling in water, which can be drunk as tea (Khan *et al*., 2017; Onyeabo *et al*., 2017).

Ginger (*Zingiber officinalis Roscoe*) belongs to the Zingiberaceae family, one of the widely used herbs and spices in large varieties of food and beverages across the world. It is also known to have therapeutic properties as it contains many biologically active compounds which contribute to health benefits. (Alayi, *et al*., 2020). Ginger has revealed good antimicrobial consequences against both gram-negative and positive bacteria. It may help to regulate blood pressure in humans by stimulating the physiological system. (Nair, 2019). Since ancient times in Asian, Arabic, and Indian herbal ethnic rhizome or stem of the plant has been used as a medication. The ginger rhizome can be used in the form of flavouring in tea, a fresh paste of ginger, preserved slices, and a dried powder. (Ozola *et al*., 2019). Ginger possesses life improving potential and other pharmacological activities such as anticancer, anti-diabetes antioxidant, antimicrobial, anti-neuroinflammation, chemotherapy-induced nausea, and vomiting (Nile and Park, 2015; Zhu *et al*., 2018; Crichton *et al*., 2019; Mao *et al*., 2019). Recently the demand and use of ginger and its products (gingerbread, ginger cake, ginger coffee, ginger drink, ginger oil, ginger spice, ginger syrup, and ginger wine) in households, pharmaceutical, brewery, food, and other related industries have skyrocketed (Bag, 2018; Sowley and Kankam, 2019).

This study was conducted to evaluate the production of herbal tea blends from Zobo and Jacobinia fortified with ginger.

MATERIALS AND METHOD

Sample Collection and Identification

Fresh ginger stem and Zobo leaves were purchased at Akpan Andem Market in Uyo Local Government Area, while fresh Justicia carnea leaves were harvested from a garden at Ekemba Nsukkara off Orok Street all in Akwa Ibom State Nigeria. The chemicals used were of analytical grade.

Methods of Tea Production

Preparation and Formulation of Sample

The plant material were thoroughly examined, and any extraneous objects were removed. A flowing tap was used to wash the samples. Samples were fragmented into small bits to facilitate quick drying. They were spread out on an oven sheet and put inside the oven after being plated on a sieve and drained and dried at 65°C. They were thereafter ground in an electronic Binatone blender to produce a semi-coarse sample and stored in a ziploc bag with the labels "Zobo powder," "Jacobinia leaf powder," and "ginger powder," respectively. Using a computerized weighing balance, the formulations for each sample were measured according to their percentage and then categorized into samples A through E using ziploc bags. 5g of each sample were measured out of the ziploc bag and placed into non-drip tea bags. These were then sealed with a sealing machine. The tea bags were designated A through E and kept in glass jars with tight lids (Figure 1).

As a control, 5g of Zobo was measured and placed into a non-drip tea bag. Glass jars were kept for sensory examination at ambient temperature and out of direct sunlight.

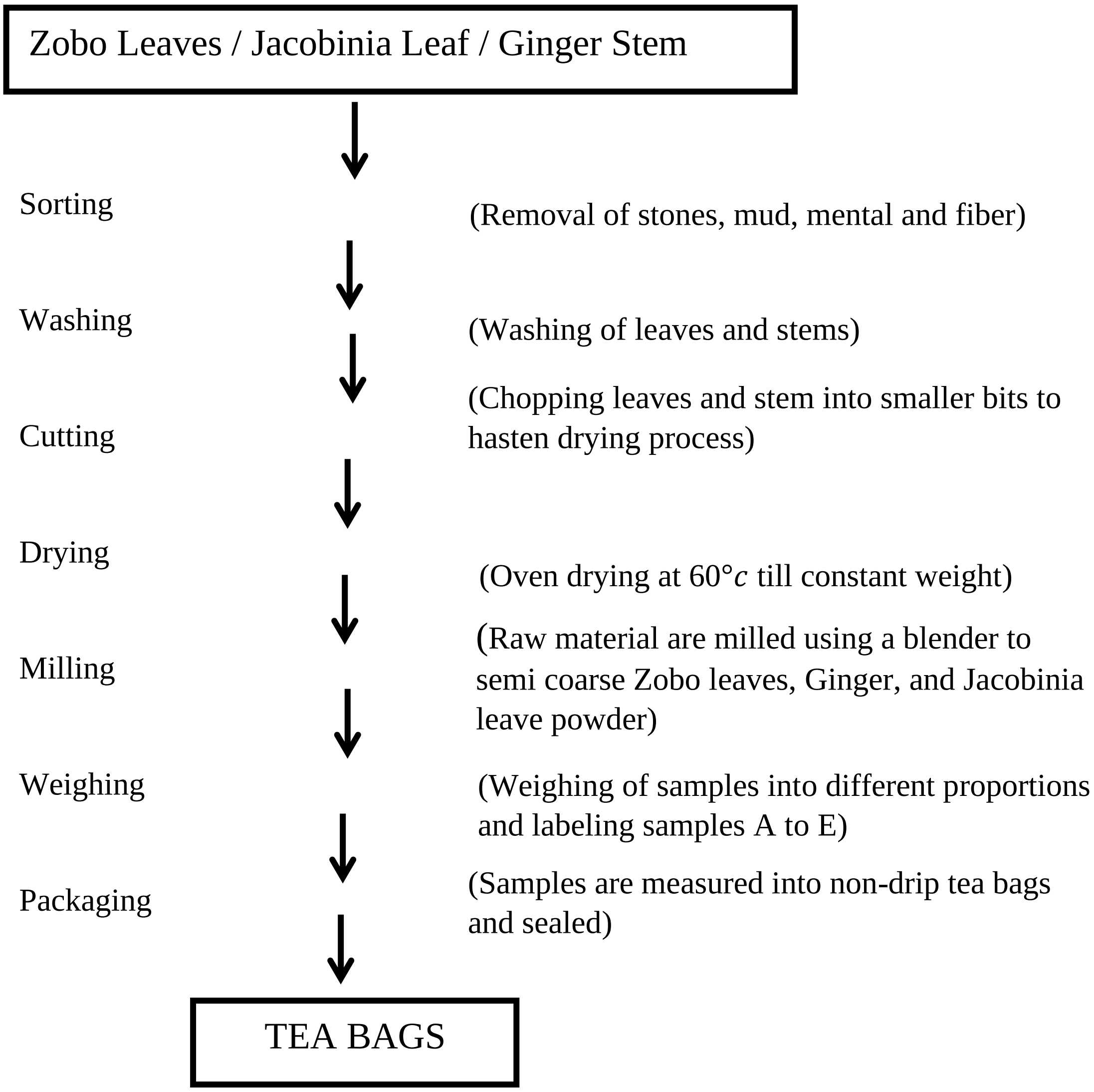

Figure 1 Flow diagram for Herbal Tea production from blends of Zobo leaves, Jacobinia leaves and Ginger rhizoid.

Source: Mohammed *et al*., (2017) with slight modification.

Products Formulation

The blends were formulated by mixing Zobo, Jacobinia and Ginger. Four samples of tea blends were produced by mixing the composite flour in different proportions (90:0:10, 70:20:10, 60:30:10, 50:40:10).

Table 1 Proportion of herbs in blended products

Product code	**Zobo Leaf *(Hibiscus sabdariffa)***	**Jacobinia Leaf *(Justicia carnea)***	**Ginger *(Zingiber officinale)***
Sample A	90	0	10
Sample B	70	20	10
Sample C	60	30	10
Sample D	50	40	10
Sample E (Control)	100	0	0

Where Sample:

A= Zobo 90%, Jacobinia 0%, Ginger 10%

B = Zobo 70%, Jacobinia 20%, Ginger 10%

C = Zobo 60%, Jacobinia 30%, Ginger 10%

D= Zobo 50%, Jacobinia 40%, Ginger 10%

E = Zobo 100%

ANALYSIS

Sensory Evaluation

Sensory evaluation was carried out using acceptance test. Acceptance tests were conducted on five (5) sample infusions using twenty (20) untrained panelists.

Preparation of Infusions

Infusions were prepared from all bagged samples. Five (5) bags of each sample formulation were placed in a glass jar and boiling water (1.5 litres) was poured into the jar. Distilled water was used. The formulations were allowed to infuse for 5min. the bags were then removed from the infusions. The infusions were unsweetened.

Acceptance Test

Selection of Panelist

Twenty (20) panelists were selected for the acceptance tests. Panelists were mostly students aged 18 and above, chosen on the basis of their willingness and commitment to partake in the sensory evaluation, availability and familiarity with tea in general and herb tea in particular. They were neither trained nor given prior information about the constituent ingredients from which the infusions were prepared.

Procedure for Serving Tea to Panelists

Sample infusions was alphabetically coded and served randomly to panelists. About 30 ml of each infusion were served in a 50 ml transparent cup. One sample was served at a time. Panelists were free to analyze the samples in any order of their choice. They were discouraged from conferring among one another during the analyses. The sample infusions were approximately 60°C to 70°C at the time of tasting. Panelists were required to rinse their mouths with warm water (about 60°C) before the commencement of tasting. To minimize possible carryover effects, panelists were required to rinse their mouths thoroughly with warm water (about 60°C) after each tasting and wait 5min before tasting the next sample. They were required to swallow all 30 ml of each sample; however, they were asked to hold about 10ml sample in the mouth for 5s and swallow small quantities in order to appreciate the full sensory character of the beverage. They were allowed to repeat tasting where necessary.

Scoring of Samples

The panelists were instructed to score their acceptance for 5 attributes of the infusions: taste, aroma, appearance, flavour, and overall acceptability. Where a panelist does not clearly understand the meaning of a particular attribute, explanation was provided. The panelists scored their acceptance of the attributes using a 9-point hedonic scale with 1 meaning ‘dislike very much’ and ‘9’ meaning ‘like very much’.

Proximate Composition

Standard methods described by AOAC (2010) was used for the determination of moisture, crude fat, crude protein and ash contents. Carbohydrate content was calculated by difference (AOAC, 2010).

ANTIOXIDANT PROPERTIES

Preparation of Extract

Two teabags each containing 5g of the formulated samples was Infused in 150ml of water at 100^{o}C for 15min. After 15min, the teabags were removed from the extract and allowed to cool, after which it was filtered using a funnel with cotton wool. The filtrate was subjected to evaporation using water bath (model Griffin and George: BJL-458, USA) at 50 ºC to remove the entire solvent. The crude extract obtained was then weighed and the percentage yield calculated using the formula below

$$\text{Yield (\%)} = \frac{\text{weight of extract}}{\text{Weight of original sample}} \times 100$$

The extract was then stored in an airtight bottle until needed for further use.

Determination of Total Phenolic and Total Flavonoids Content

The phenolic content of the sample was determined spectrophotometrically with folin-ciocalteu reagent using the modified method of Wolfe *et al.*, (2003) while the total flavonoids content was estimated using the procedure described by Zhisten, *et al.*, (1999).

Determination of DPPH Radical Scavenging Activity and Reducing Power Assay

DPPH free radical scavenging was evaluated according to the method of Shekhar and Auju, (2014) while the reducing power was determined using the method of Oyaizu (Oyaizu, 1986).

Determination of Mineral Elements Composition

The phenonthroline method described by Pearson (1976) was used to determine the magnesium content of the samples.

Calcium was determined using the method described by Harborne (1973), while the spectrometer molybdate method as described by Pearson (1976) was used to determine phosphorus and potassium content.

Determination of Vitamin Composition (Vitamin A and C)

Provitamin A was determined using the method of Pearson (1976). Vitamin C was determined using method of Barakat *et al.*, (1973).

PHYTOCHEMICAL ANALYSIS

Determination of Tannins, saponins, phytate and oxalate

The method of Swain (1979) was used for the determination of the tannin content of the Sample. Phytate contents were determined using the method of Young and Greaves (1940) as modified by Lucas and Markakes (1975). Oxalate contents were determined using the method of Krishna and Ranjhan (1980), while saponin was determined using the method of Trease and Evans, (1989)

Statistical Analysis

Data from mineral and vitamin composition as well as sensory evaluation were subjected to analysis of variance (ANOVA) using SPSS version 20 and difference between means was assessed by least significant different test at $p<0.05$, while means was separated using Duncan's New Multiple Range Test (DNMRT). All determinations were carried out in triplicate and data was expressed as means $\pm$ standand deviation.

RESULTS/DISCUSSION

Yield of Extract from the Dried Plant Materials

The dried plant material yielded an extract of 1.83g, 3.22g, 3.01g, 2.90g, and 1.90g for sample A, B, C, D and E respectively.

Table 2 Yield of Extract

Samples	Percentage yield (%)
A	18.3
B	32.2
C	30.1
D	29.0
E	19.0

Proximate Composition of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

The results of the nutritional composition of the herbal tea samples are presented in Table 3. The moisture content of the tea blends ranged from 2.26 to 3.73%. The values showed significant ($p<0.05$) difference between the tea samples. The results showed a lower moisture content than those reported by Olasunmbo and Mosope, (2020) who had a moisture content of 8.12%. According to Muhammad *et al.*, (2013) high levels of moisture (above 3-7%) in tea samples may result in quality deterioration. The lowest moisture content recorded for Sample A (2.26%) is an indication that the tea sample will have a longer shelf life.

The protein content ranged from 3.27% to 6.33%. Sample D had the highest protein content while sample E had the lowest. There was significant difference ($p<0.05$) between all the samples. Mohammed *et al.*, (2017) observed that protein content of roselle calyces was 7.44%, the result obtained in this study is at variance with the report of Mohammed *et al.*, (2017). According to Singh *et al*. (2018) sample with higher protein content can be recommended for people who are prone to protein malnutrition.

The lipid content of tea blends ranged from 2.21% to 3.92%. The control (Zobo 100%) had the least lipid content while sample D had the highest lipid value of 3.92%. These values were recorded to be higher than 0.46±0.04% to 0.54±0.04 reported for roselle herbal tea and roselle composite tea samples (Olasunmbo and Mosope, 2020). Plant foods are not significant sources of lipid in human diet (Spector and Kim, 2015).

The value for ash content ranged from 4.08% to 5.73%. All the tea blends showed significant difference ($p<0.05$). The ash content was in the same range as that recorded for Lipton tea (Onyeneke, 2021).

The crude fibers present in food have little food value but provide the bulk necessary for proper peristaltic action in the intestinal tract. The fibre content ranged from 7.76% to 9.61%.

The control, sample E had a high (78.82%) value of carbohydrate compared to the other tea samples with sample D having the lowest value of (70.82%). It is believed that tea does not have food value, but due to the rich nature of the raw materials used for the production of these tea blends, the carbohydrates content is high and this makes the tea nutritious.

Table 3 Proximate Composition of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
A	$2.26^{e} \pm 0.04$	$4.64^{d} \pm 0.08$	$2.59^{d} \pm 0.06$	$4.08^{d} \pm 0.06$	$8.62^{d} \pm 0.06$	$77.78^{b} \pm 0.10$
B	$2.78^{d} \pm 0.07$	$5.52^{c} \pm 0.06$	$3.14^{c} \pm 0.06$	$4.25^{c} \pm 0.05$	$8.78^{c} \pm 0.06$	$75.49^{c} \pm 0.09$
C	$3.31^{c} \pm 0.04$	$5.86^{b} \pm 0.10$	$3.65^{b} \pm 0.07$	$4.84^{b} \pm 0.05$	$9.18^{b} \pm 0.08$	$73.16^{d} \pm 0.08$
D	$3.50^{b} \pm 0.14$	$6.33^{a} \pm 0.07$	$3.92^{a} \pm 0.05$	$5.73^{a} \pm 0.05$	$9.61^{a} \pm 0.06$	$70.82^{e} \pm 0.15$
E	$3.73^{a} \pm 0.06$	$3.27^{e} \pm 0.05$	$2.21^{e} \pm 0.10$	$4.16^{e} \pm 0.06$	$7.76^{e} \pm 0.05$	$78.82^{a} \pm 0.08$

Values are means ± standard deviations of the sensory scores. Means with different superscript on the same column are significantly ($P<0.05$) different.

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Phytochemical Composition of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Phytochemicals are chemicals produced by plants and also refer to only those chemicals which may have an impact on health, or on flavour, texture, smell or colour of the plants but are not required by humans as essential nutrients (Kumar *et al.*, 2023). From the result, significant ($p<0.05$) differences existed among all the samples in their phytochemical content.

Tannins content ranged from 3.86 mg/100g to 2.34 mg/100g. Tannin content in the tea blends were higher than those reported by some researchers (Zhang *et al.*, 2019; Ryou *et al.*, 2012) in black tea. Tannins possess anti-cancerous, antimicrobial, anthelmintic, anti-viral and wound healing properties but under certain consumption conditions, cause reduced digestibility, anti-nutritional effect, cancer inducer and many other diseases (Sharma *et al.*, 2019). The importance of tannins in promoting glucose absorption, thereby reducing the risk of diabetes has also been established (Kumari and Jain, 2015).

Phytate value of prepared tea blends ranged from 3.59% to 6.75% with sample E having the highest content while sample A had the least phytate content. There were significant differences amongst samples C, D and E ($p <0.05$) while samples A and B were statistically similar (at $p <0.05$). These values were observed to be higher than 0.38 mg/g and 0.90 mg/g repectively recorded from Banana (*Musa acuminate*) and Zobo (*Hibiscus sabdariffa*), Arowolo *et al.*, (2021).

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 (Kumar *et al.*, 2010).

Results of oxalate content ranged from 5.17 mg/100g to 10.25 mg/100g with sample D having the highest (10.25) while sample A had the least (5.17). These values were observed to be higher than 4.68 mg/g and 1.15 mg/g reported for black tea and green tea respectively (Chabi *et al.,* 2018). The presence of high content of oxalate is an indication of toxicity level. Therefore, oxalate at low level confers antioxidant activity in both food and human (Garcia-valle, 2019).

The saponin content shown in Table 4 of the herbal tea blend ranged from 0.14 mg/100g to 0.56 mg/100g. It was observed that Sample D had the highest saponin content (0.56) while sample A had the least (0.14). This result showed that the tea blends contain lower saponin content than 1.04 mg/g to 1.75 mg/g in Banana (*Musa acuminate*) leaf and Zobo (*Hibiscus sabdariffa*) respectively (Arowolo *et al.,* 2021).

Table 4: Phytochemical of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Tannin (mg/100g)	Phytate (mg/100g)	Oxalate (mg/100g)	Saponin (mg/100g)
A	$2.34^{e} \pm 0.05$	$3.59^{d} \pm 0.10$	$5.17^{e} \pm 0.05$	$0.14^{d} \pm 0.04$
B	$3.15^{d} \pm 0.05$	$3.64^{d} \pm 0.05$	$6.36^{d} \pm 0.06$	$0.33^{b} \pm 0.04$
C	$3.46^{c} \pm 0.05$	$4.16^{c} \pm 0.04$	$9.31^{b} \pm 0.05$	$0.37^{b} \pm 0.05$
D	$3.56^{b} \pm 0.04$	$5.08^{b} \pm 0.02$	$10.25^{a} \pm 0.04$	$0.56^{a} \pm 0.03$
E	$3.86^{a} \pm 0.02$	$6.75^{a} \pm 0.05$	$8.38^{c} \pm 0.03$	$0.24^{c} \pm 0.04$

Values are means ± standard deviations of the sensory scores. Means with different superscript on the same column are significantly ($P<0.05$) different.

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Mineral Content of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Minerals are nutrients that are as essential as our need for oxygen to sustain life. They are found in organic and inorganic combinations in food (Soetan *et al.,* 2010). The calcium content of the herbal tea ranged from 50.70 mg/100g to 9.81 mg/100g. The value decreased significantly ($p<0.05$) as the proportion of Jacobinia decreases. The calcium content of all the tea blend was higher than 14.8mg/100g reported by Luvonga *et al.*, (2010) for roselle powder but lower than 60 mg/100g reported by Mohamed *et al.,* (2012) for dried roselle calyces.

The potassium content ranged from 15.86 mg/100g in sample D to 8.26 mg/100g in sample E. There was no significant difference ($p<0.05$) between samples C and D while A, B, and E were significantly different. The potassium content of all the tea blends were lower than 101.5 mg/100g reported by Luvonga *et al.,* (2010) for roselle powder. According to Androgue and Madias, (2007), potassium intake is required in relatively large amount in the body because it functions as an important electrolyte in the nervous system.

The result for magnesium content showed that the magnesium content of the tea varied from 4.35 mg/100g to 33.54 mg/100g. Sample E had the least magnesium content while sample D had the highest. The values decreased significantly ($p>0.05$) as the concentration of Jacobinia decreased. Magnesium is required for many enzyme activities, particularly those utilizing an ATP- Mg2+complex, and for neuromuscular transmission (Chaney, 2011).

The results for the phosphorus content showed that there existed a significant difference among all the samples. The least value for phosphorus content was seen in sample E (6.17 mg/100g) and the highest value for magnesium content was seen in sample D (34.17 mg/100g).

Table 5 Mineral Content of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Calcium (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)	Phosphorus (mg/100g)
A	$13.18^{d} \pm 0.08$	$8.37^{d} \pm 0.05$	$11.06^{c} \pm 0.05$	$7.53^{d} \pm 0.05$
B	$43.25^{c} \pm 0.05$	$28.19^{c} \pm 0.08$	$14.59^{b} \pm 0.03$	$30.48^{c} \pm 0.07$
C	$48.32^{b} \pm 0.06$	$31.33^{b} \pm 0.07$	$15.64^{a} \pm 0.05$	$33.32^{b} \pm 0.06$
D	$50.70^{a} \pm 0.06$	$33.54^{a} \pm 1.17$	$15.86^{a} \pm 0.05$	$34.17^{a} \pm 0.07$
E	$9.81^{e} \pm 0.09$	$4.35^{e} \pm 0.04$	$8.26^{d} \pm 0.06$	$6.17^{e} \pm 0.04$

Values are means ± standard deviations of the sensory scores. Means with different superscript on the same column are significantly (P<0.05) different.

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Vitamin Content of Herbal Tea Blend

Vitamins are organic compounds that our bodies require in very small amounts for variety of metabolic processes. Some have blood-boosting effects and others have anti-oxidant properties which include A, C and E. The vitamin A contents of the tea blends ranged from 3.42 mg/100g to 5.16 mg/100g. The vitamin A content showed that there existed a significant difference (p<0.05) among all the samples. Vitamin C value ranged from 55.10 mg/100g to 72.53 mg/100. The vitamin C content of the tea blends was slightly lower than 80 mg/100 g reported by Mohamed *et al.*, (2012) for dried roselle calyces but significantly higher than 32.36 mg/100 g reported by Ameh *et al.*, (2009) for dried roselle calyces. This might be attributed to the source and the rate of dryness of the herbal tea.

Table 6: Vitamin Content of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Vitamin A (mg/100g)	Vitamin C (mg/100g)
A	$3.82^{e} \pm 0.09$	$61.90^{b} \pm 0.04$
B	$4.21^{c} \pm 0.10$	$57.33^{c} \pm 0.07$
C	$4.64^{b} \pm 0.05$	$55.78^{d} \pm 0.07$
D	$5.16^{a} \pm 0.05$	$55.10^{e} \pm 0.07$
E	$4.61^{b} \pm 0.09$	$72.53^{a} \pm 0.08$

Values are means ± standard deviations of the sensory scores. Means with different superscript on the same column are significantly (P<0.05) different.

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Sensory Evaluation of Tea Blends

The results for the sensorial attributes of the formulations indicated that the composite blends differed in some sensorial attributes evaluated. The results indicated that sample B was rated highest among the three composite blends in all the attributes evaluated. The scores for overall acceptability indicated that the products were highly accepted by the panelists. However, sample A (7.33) was most preferred.

Table 7: Mean Sensory Scores of Herbal Tea Blends from composite blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Appearance	Aroma	Taste	Mouthfeel	Overall acceptability
A	$6.92^a \pm 1.56$	$6.50^a \pm 1.08$	$6.42^a \pm 1.50$	$6.50^a \pm 2.06$	$7.33^a \pm 0.98$
B	$7.50^a \pm 1.62$	$6.92^a \pm 1.56$	$6.67^a \pm 1.72$	$6.50^a \pm 1.93$	$7.25^a \pm 1.86$
C	$6.92^a \pm 1.73$	$6.58^a \pm 1.08$	$6.42^a \pm 1.67$	$6.50^a \pm 1.67$	$7.08^a \pm 0.99$
D	$6.67^a \pm 1.72$	$6.92^a \pm 1.24$	$6.42^a \pm 1.31$	$6.50^a \pm 1.44$	$6.42^a \pm 1.50$
E	$6.92^a \pm 1.37$	$5.92^a \pm 0.99$	$6.17^a \pm 1.19$	$6.25^a \pm 1.54$	$6.83^a \pm 1.19$

Values are means ± standard deviations of the sensory scores. Means with different superscript on the same column are significantly ($P<0.05$) different.

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Total Phenolic and Total Flavonoid Content of Herbal Tea Blends

Table 8 shows the result of the total phenolic and total flavonoid content of the different samples. The results for the total phenolic content showed that sample E had the highest phenolic content (20.991 mgGAE/g) followed by sample A (8.861 mgGAE/g), sample C (4.417 mgGAE/g), sample D (2.287 mgGAE/g) and finally sample B (1.176 mgGAE/g) respectively. The significant difference among the samples may be attributed to the variation in the extract composition. The result obtained was lower than that obtained by Chen *et al.*, 2010 from C. sinensis 60.60 to 141.20 mgGAE/g. Plant phenolic compounds are natural antioxidants and have the potential to donate hydrogen atoms to the radical and make them stable (Goupy *et al.*, 2003).

The results for the total flavonoid content showed similarities with the total phenolic content with sample B having the highest phenolic content of 85.5 mgQE/g, followed by sample E (84.5 mgQE/g), sample C (83.5 mgQE/g), sample A (81.5 mgQE/g) and finally sample D (71.5 mgQE/g). Barreira *et al.*, (2013) reported that total flavonoid content in C. sinensis tea was 0.13 mgCE/ml which is lower that obtain from this report. Therefore, the herbal tea produced had higher flavonoid content.

Table 8: Total Phenolic and Total Flavonoid Content of Extract Prepared from the Composite Blend of Zobo leaf, Jacobinia leaf and Ginger

Sample	Total Phenolic (mgRE/g)	Total Flavonoid (mgQE/g)
A	8.861	81.5
B	1.176	85.5
C	4.417	83.5
D	2.287	71.5
E	20.991	84.5

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10 and E = 100:0:0

Table 9: Effective concentration IC_{50} Values (µg/ml) of Tea and Ascorbic acid

Sample	DPPH (IC_{50})[a]	Reducing Power (IC_{50})[b]
A	60 µg/ml	> 100 µg/ml
B	75 µg/ml	> 100 µg/ml
C	88 µg/ml	> 100 µg/ml
D	100 µg/ml	> 100 µg/ml
E	40 µg/ml	67 µg/ml
Ascorbic Acid	10 µg/ml	30 µg/ml

[a]IC_{50} (µg/mL): effective concentration at which 50 % of DPPH radical are scavenged

[b]IC_{50} (µg/mL): effective concentration at which absorbance is 0.5.

DPPH Radical Scavenging Activity and Reducing Power Assay of Herbal Tea Blends

The value of DPPH radical scavenging activity is strongly influenced by the concentration of antioxidants. The higher the concentration of antioxidants, the higher the activity. From Fig 2 and Fig 3 was observed that there was a constant increase in the absorbance of the samples as the concentration increased with the highest absorbance value recorded in ascorbic acid that was used as a positive control.

Plants are viewed as rich source of natural antioxidants. Secondary metabolites like phenolics and flavonoids from plants have been reported to be potent free radical scavengers (Odukoya *et al.*, 2006).

The IC50 value of the tea blend ranged from 40 to 100µg/ml. Sample D had a higher IC50 value of 100µg/ml than that reported for the standard ascorbic acid with a lower DPPH value of IC50 (10µg/ml). Therefore, this indicates a better antioxidant activity of the herbal tea blends. The use of DPPH assay provides an easy and rapid way to evaluate antioxidants by spectrophotometry (Huang *et al.*, 2005). The high phenolic and flavonoid content of the tea extracts may be responsible for its high DPPH scavenging activity.

The results from the Reducing Power Assay at (IC50) indicate higher value from that of the standard. Sample A to D shows higher Reducing power greater than 100µg/ml while sample E had an IC50 value of 67µg/ml. The ascorbic acid recorded a lower IC50 value of 30µg/ml. FRAP assay measures the reducing ability of antioxidants against oxidative effects of reactive oxygen species. The antioxidative activity is estimated by measuring the increase in absorbance caused by the formation of ferrous ions from FRAP reagent. The ferric [Fe (III)] complex undergoes reduction to a coloured ferrous [Fe (II)] complex at low pH. Increasing absorbance indicates an increase in the reductive ability. The absorbance is measured spectrophotometrically at 593 nm (Benzie and Strain, 1996).

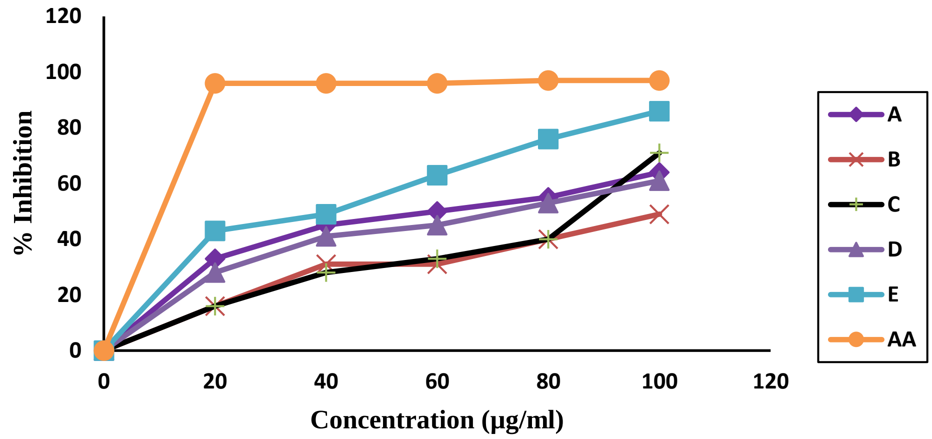

Fig. 2: DPPH Scavenging Activity of Herbal Tea and Ascorbic Acid

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10, E = 100:0:0, AA = Ascobic Acid

Reducing Power Assay

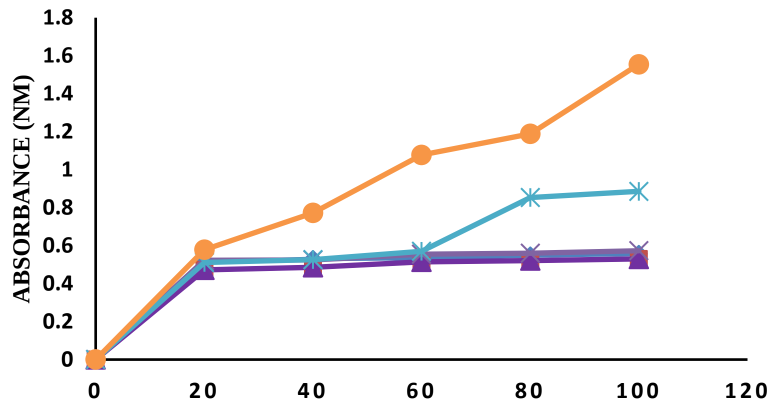

Fig. 3: Reducing Power Activity of Herbal Tea and Ascorbic Acid

Keys: A = 90:0:10, B= 70:20:10, C = 60:30:10, D = 50:40:10, E = 100:0:0, AA = Ascobic Acid

CONCLUSION AND RECOMMENDATION

CONCLUSION

The production and evaluation of the herbal tea blends from Zobo leaf and Jacobinia leaf fortified with Ginger have yielded promising results. The careful selection and proportioning of ingredients, coupled with the fortification with ginger resulted not only in a rich and flavourful tea but also in a tea with outstanding potential health benefits. The sensory analysis highlighted favorable attributes and panelist feedback indicates a positive reception.

RECOMMENDATION

The herbal tea blends produced in this study showed significant nutrient contents. However, further studies could be done on microbiological analysis of the tea as well as other mineral content.

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