



Nutrient Composition of *Brillantaisia guianensis* P. Beuv Leaves

Kalu E. Chinedu^{1*}, Eugene N. Onyeike¹ and Catherine C. Ikwuchi¹

¹*Department of Biochemistry, Faculty of Science, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All the authors designed the study, Author KEC performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Authors ENO and CCI managed the analyses of the study and edited the final draft. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The quantitative nutrient composition of leaves of *Brillantaisia guianensis* P. beuv was investigated.

Source and Identification of Sample: The leaves of *B. guianensis* used in this study were harvested fresh from Ude plantation in Okon Aku, Ohafia Local Government Area of Abia State, Nigeria. They were identified by a Taxonomist (Dr Edwin Wosu) in the Herbarium Unit of the Department of Plant Science and Biotechnology, University of Port Harcourt.

Study Design: The study was designed, using standard methods, to determine the proximate, amino acids, minerals and vitamins composition of the leaves.

Results: The wet leaves were high in moisture (88.4%) while the dried sample had practically no moisture, indicating that the wet leaves could easily be prone to microbial spoilage due to high water activity. Drying increased protein level from 3.50 to 28.0% and ash from 2.36 to 27.7% among other parameters. The low calorific values for wet sample (16.1 kcal/100 g) and dry sample (152.3 kcal/100 g sample) showed that the leaves are poor energy-giving foods. However, the leaves contain good amino acid profile especially the essential amino acids (valine, threonine, isoleucine, leucine, lysine, methionine, phenylalanine and tryptophan). The nutrient mineral (Na,

*Corresponding author: E-mail: kaluchinedu54@yahoo.com;

Ca, Mg, K, Se, P, Fe) levels were high to supply the World Health Organization recommended daily allowance for adults and children. The sample contains appreciable amount of fats and water - soluble vitamins required for growth.

Conclusion: The results show that the leaves are good sources of essential and non-essential amino acids, minerals and vitamins adequate to meet the required daily allowance for nourishment of the body.

Keywords: *Brillantasia guinens peuv* leaves; nutrient composition.

1. INTRODUCTION

Plants are important source of valuable source of valuable nutrients. They constitute an indispensable part of human diet in developing and under-developed nations most particularly in Africa. Subukola et al. [1] had noted that beside the varieties, plants add to the menu, they are valuable sources of nutrients especially in developing and under- developing areas where they contribute essentially to protein, minerals, vitamins, fibers and other nutrients which are usually in short supply in daily diets [2]. In addition, plant extracts have also been used as medicines by traditional medicine practitioners since time immemorial [3,4] It is worthy of note that consumption of numerous types of edible plants as sources of food could be beneficial to nutritionally marginal population especially in developing countries where poverty and climate change are causing havoc to rural populace [5]. However, low consumption of green leafy vegetables in diet is one of the major factors which leads to deficiency of vitamins and iron. Minerals and vitamins cannot be synthesized by animals and must therefore be provided from plants or vitamins and mineral-rich water bodies.

B. guinensis p.beuv is a perennial herbaceous shrub. Its common name is Giant Tropical Blue African Salvia, (*Acanthaceae*).The genus *Brillantaisia* has more than 20 species that are distributed in tropical Africa. *B. guianensis* as a perennial shrub grows up to about 1.5 m high and are found in Central and West Africa as well as East Camerouns. *B. guianensis* is widely used in African traditional medicine to treat skin infections and tooth-ache, [6,7], It has been shown to possess antinociptive effects [5] or are traditionally used for their antihypertensive action [7]. In Cameroon, the decoction of *B. guianensis* is used by traditional healers of Central Province for the management of cardiovascular diseases especially hypertension.

Several researches have validated the medicinal value of *B. guianensis*. The methylenechloride/

methanol leaf extract of *B. guianensis* had been reported to lower arterial blood pressure and heart rate of normotensive Wistar rats, [8].The relaxant effects of *B. guianensis* on rats vascular smooth muscle had also been reported [9]. It is also known to show haematinic activity [10]. In South Eastern Nigeria with high prevalence of both malaria induced and iron deficiency anaemia, aqueous decoctions of the leaves of *B. guianensis* are very popular among village women in combating malaria induced anaemia in children [11]. The root taken as soup in Southern Nigeria is used to reduce pain during pregnancy [12]. In Ohafia, in Abia State of Nigeria, the leaves are used in the treatment and management of diabetes mellitus.

The present study therefore was aimed at evaluating the nutrient profile of *B. guianensis*.

2. MATERIALS AND METHODS

2.1 Reagents Used

All the reagents used in this research were obtained commercially and were of analytical grade.

2.2 Collection of Plant Material

The leaves of *B. guianensis* used in this study were harvested fresh from Ude Plantation in Okon Aku, Ohafia Local Government Area of Abia State and was identified and given a voucher number of (EH-P-052) by a Taxonomist in the Herbarium Unit of the Department of Plant Science and Biotechnology, University of Port Harcourt, Dr Edwin Wosu.

2.3 Sample Preparation

The harvested plant leaves were destalked, washed under running tap water and rinsed with distilled water. The clean leaves were divided into two. The first portion was used for proximate analysis while the other portion was dried in an oven at 60°C for 24 hours. The dried leaves were

ground into a fine powder using mortar and a pestle and sieved to pass through a 40 mesh sieve and stored in an airtight container under refrigerated temperature for further use.

2.4 Determination of Chemical Composition

The lipid, moisture and ash contents of the leaves were determined by using standard AOAC Methods [13]. Total carbohydrate was determined by the Difference method, by subtracting the sum of percentage moisture, crude fat, crude protein, ash and fibre from 100. That is, Total carbohydrate = $100 - (\% \text{ moisture} + \% \text{ crude fat} + \% \text{ crude protein} + \% \text{ fibre})$ as reported by Onyeike and Acheru [14]. While crude protein was by macro-Kjedahl method as described by Pellet and Young [15]. The nitrogen value was converted to protein by multiplying by a factor of 6.25. Determination of crude lipid of the sample was done using soxhlet type and the direct solvent extraction method [16]. The energy value content was calculated by multiplying the mean values of crude protein, crude fat and total carbohydrate by the Atwater factors of 4,9,4 respectively, taking the sum of the products and expressing the results in kilocalories per 100 g sample as reported by Onyeike et al. [16] and Ihekoronye and Ngoddy [17]. All the proximate values were reported in percentage [18,19].

2.5 Determination of Mineral Composition

The AOAC Official Method 985.01 [13] was adopted with modification.

Ashing: A one gram of the pulverized sample was weighed and placed in a Petri-dish on the laboratory bench before the analysis. The sample in the Petri-dish was emptied into the muffle furnace pot. The pot with its content was placed in the furnace at 550°C for 4 hours. After this, the sample in the pot was removed from the furnace and allowed to cool in the desiccators after which the process was repeated until a constant weight was obtained.

Then, 0.2 g of the ashed sample was weighed into the pre-cleaned borosilicate 250 mL capacity beaker for digestion and 30 ml of 1M nitric acid was added into the weighed sample in the beaker. The sample in digesting solvent was placed on the hot plate for digestion in the fume cupboard. The beaker and its content after the digestion were allowed to cool. Another 20 ml of the digesting solvent was added further in the

fume cupboard and the mixture was allowed to cool to room temperature. The mixture was filtered into the 250 mL volumetric capacity borosilicate container using filter paper. The filtrate was made up to the mark with the deionized water. The same procedure was followed for the digestion of the other samples.

All the digested samples were sub-sampled into pre-cleaned borosilicate glass containers for atomic Absorption Spectrophotometer analysis.

Standards of iron, copper, cobalt, manganese, selenium, calcium, magnesium, potassium and sodium solutions of 0.2, 0.4, 0.6, 0.8 and 1.0 mg/mL were made from each of the heavy metal solutions of 1000 mg/mL³ stock solutions of the analytes. The set of standard solutions and the filtrate of the digested samples were analyzed by AAS. The detection limit of the metals in the sample was 0.0001 mg/L by means of the UniCAM 929 London, Atomic Absorption Spectrophotometer powered by the SOLAR software. Iron, copper, cobalt, manganese, selenium, calcium, magnesium, Potassium and sodium cathode lamps were used for the analysis of the respective mineral ions in the standard and the filtrate of the samples. Gas mixtures were used in the generation of the flame.

2.6 Determination of Phosphorus Concentration

Twenty five grams of the sample was weighed into a Schoniger flask and burnt in excess oxygen gas. The product was digested with 1M nitric acid. The content was boiled for a minute to ensure complete conversion of phosphorus pentoxide to orthophosphate.

The solution was passed through a 10 cm long resin column, and the filtrate was collected, in a 10 mL Pyrex test tube, 2 mL of 2.5% ammonium molybdate solution which is the color development reagent was added for the absorbance reading at 650 nm for both the standards and the sample filtrate.

2.7 Determination of Vitamin

The samples were extracted following the method of Zhao et al. [20] with slight modification.

Procedure

The plant sample was weighed and pulverized into fine powder, using Janke and kunkel

(LARBORTECHNIC) grinder. One gram of the pulverized sample was homogenized in 1 mL of ethanol, and extracted by refluxing with 10 mL of the re-distilled methanol, for 6 hours at very low temperature. The process was repeated twice, using fresh solvents, to ensure that most of the water soluble vitamins in the pulverized samples were removed. Another 1 g of the pulverized sample was homogenized in 1 mL of ethanol, and extracted by refluxing with 10 mL of chloroform, for 6 hours at very low temperature of 4°C. The process was repeated twice, using fresh solvents to ensure that most of the fat soluble vitamins in the pulverized samples were removed. Both extracts were then evaporated to dryness on a rotary evaporator. Their residues were combined, before adding 4.00 mL of 7% Boron Trifluoride reagent and heated for 45 mins in an oven at 100°C. It was cooled to room temperature, and 1.0 g of anhydrous Na₂SO₄ was added to remove water, after which it was subjected to gas chromatography analysis, using pulse flame photometric detector, for the determination of the component vitamins.

Standard solutions were prepared and the linearity of the dependence of response on concentration was verified by regression analysis. Identification was based on the comparison of retention times and spectral data with standards. Quantification was performed by establishing calibration curves for each compound determined, using the standards.

Chromatographic Conditions: The gas chromatograph used was an HP 6890 (Hewlett Packard, wellington, DE, USA) fitted with flame ionization detector (FID), powered with HP Chemstation Rev. A 09.01 (1206) software, to identify and quantify compounds. The column was a capillary of HP-5 column with a dimension of (30 m x 0.32 mm x 0.25 µm) thickness. The Injection temperature was 250°C and detector temperature 320°C. Split injection was adopted with a split ratio of 20:1. The Carrier gas was nitrogen gas. Hydrogen and Compressed air Pressures were 20 psi and 30 Psi respectively. The oven was programmed as follows: Initial Temperature was at 30°C for 2 min and then programmed for 15min before changing to 15°C/min for 2 min.

2.8 Determination of Amino Acid

The crude protein content was determined according to AOAC Official Method 2001.11 [13], while the amino acid profile of the sample was

determined using the method described by Spackman et al. [21].

Procedure

Defatting of sample: Ten grams of the pulverized, dried and water-free sample was weighed into 250 mL conical flask and defatted by extracting three times with 30mL of petroleum ether (60-80°C), in a soxhlet extractor.

Nitrogen Determination: Two grams of the defatted sample was placed on a cigarette foil and folded before transferring into the 100 mL kjeldhal flask with 2 mL of deionized water, 0.1 g of pumice (anti- bumping) granules, 1.33 g of catalyst, and 1.5 mL of concentrated sulphuric acid were added to the sample in the flask. It was heated until frothing stopped which was an indication of completion of digestion. This was allowed to cool for 30 min. After this, 10 mL of deionised water was slowly added to the mixture in the flask. A graduated 250 mL Erlenmeyer (receiver) flask containing 5 mL of 2% boric acid was placed under the condenser of the distillation apparatus, with the tip below the solution. The flask with digested sample was attached to the jet arm of distillation apparatus. Then, 10 mL of 50% NaOH-Na₂S₂O₃ solution was added through funnel stopcock, leaving 1 mL of the NaOH solution in the funnel, which was rinsed with 15 mL of deionised water into the flask. The mixture was distilled until the distillate reached the 35 mL mark on the receiver (flask) before removing the receiver flask and rinsing the condenser tip with deionised water. The content of the boric acid receiving solution was titrated with the standard 0.01M sulphuric acid, to the first pink colour. The percentage nitrogen in the original sample was calculated using the formula:

$$\text{Kjeldhal nitrogen titre (\%)} = \frac{(V_b - V_s) * M * 1.401 * 20}{W}$$

Where

- V_b = volume (ml) of NaOH used for blank titration
- V_s = Volume(ml) of NaOH used for sample titration
- M_b = molarity of the base used
- W = weight(g) of sample used
- 1.4007 = milli-equivalent weight of nitrogen since 5ml of digest is used for titration out of the 100 ml final stock.
- 20 = dilution factor

The crude protein content was obtained as follows:

Crude protein content (%) = % nitrogen × 6.25

Where 6.25= factor to convert N to protein.

Hydrolysis of the Sample: The defatted sample (0.1 g) was weighed into a glass ampoule. Then, 7 mL of 6M HCl was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid oxidation of some amino acids like methionine and cysteine, during hydrolysis). The glass ampoule was then sealed with Bunsen flame and put in an oven at 105°C for 22 mins and the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40°C under vacuum in a rotary evaporator. The residue was dissolved in 30 mL re-distilled methylene chloride before concentrating to 1mL for gas chromatographic analysis.

Loading of the hydrolysate into the gas chromatograph for analysis: Standard solutions were prepared and the linearity of the dependence of response on concentration was verified by regression analysis. Identification was based on comparison of retention times and spectral data with standards. Quantification was performed by establishing calibration curves for each compound determined, using the standards.

Chromatographic conditions for the determination of amino acid: The gas chromatograph used was an HP 6890 (Hewlett Packard, wellington, DE, USA) fitted with flame ionization detector (FID), powered with HP Chemstation Rev.A 09.01(1206) software, to identify and quantify compounds. The column was a capillary HP-5column of dimension (30 m x0.32 mm x 0.25 µm) thickness. The Injection temperature was 250°C and detector temperature 320°C. Split injection was adopted with a split ratio of 20:1. The Carrier gas was hydrogen gas. Hydrogen and Compressed air Pressures were 20 psi, and 35Psi respectively. Oven was programmed as follows: Initial Temperature was at 60°C. First ramping was at 8°C /min for 20 min and maintained for 2 min while Second ramping was at 12°C/Min for 6min and maintained for 2 minutes.

2.9 Determination of Chemical Scores of Protein

The chemical score of the protein was determined by comparing amino acid

composition obtained herein, with WHO reference proteins [22], according to the following formula:

$$\text{Chemical score (\%)} = \frac{\text{Amount of a particular essential amino acid in a given quantity of the test protein}}{\text{Amount of same amino acid in the same quantity of the reference protein}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of the leaves of *B. guianensis*

The leaves had moisture content of (88.4%), protein content (3.5% wet weight and 28.0% dry weight), lipids (>0.01% wet weight and 2.10% dry weight), total carbohydrate (0.49% wet weight and 5.34% dry weight), ash content (2.36% wet weight and 27.7%), crude fiber (5.24% wet weight and 36.86%), and caloric value of (16.05% wet weight and 152.26% dry weight).

3.2 Amino Acid Composition of the Leaf Proteins

The amino acid profile and chemical scores of the proteins from the leaves of *B. guianensis* are presented in Tables 2 and 3 respectively. The leaves has a slightly higher content of non-essential amino acids than essential amino acids, sulphur-containing amino acids (6.96%), and aromatic amino acids (9.57%). It is very rich in glutamate (20.19%), and contain all the essential amino acids. Every 100 g of the proteins from *B. guianensis* contain 414 mg of essential amino acids, 21.23 mg sulphur - containing amino acids and 82.5 mg aromatic amino acid. There is no limiting amino acid in the leaves of *B. guianensis*. The leaves had high amino acids score for histidine, isoleucine, phenylalanine and valine.

3.3 Mineral Composition of *B. guianensis*

The concentration of the mineral elements present in the leaves of *B. guianensis* is presented in Table 4. The leaves had high potassium and magnesium content, moderate calcium, phosphorus and selenium composition but very low iron, copper, manganese and copper content. When compared with WHO recommended daily allowance most of the mineral found in *B. guianensis* can meet the required daily amount for normal nourishment.

3.4 Vitamins composition of *B. guianensis*

The concentration of vitamins in *B. guianensis* is presented in Table 5. Among the ten vitamins detected only vitamin C was in high amount of 19.0 mg/L, vitamin B₃ (7.75 mg/L) and vitamin E (6.62 mg/L) were moderately high and the rest in very minute quantity. When compared with WHO RDA [23] a 100 g of the leaves *B. guianensis* can meet up the required daily allowance for vitamins B₅, B₆, B₉, C and K.

Table 1. Proximate composition of the leaves of *B. guianensis*

Parameters	% Wet weight	%Dry wet
Moisture	88.4±2.3	-
Crude protein	3.50±0.11	28.0±0.50
Crude fat	<0.01±0.002	2.10±1.30
Crude fiber	5.24±0.12	36.86± 0.40
Ash	2.36±0.16	27.7±1.40
Total carbohydrate	0.49±0.03	5.34±0.40
Caloric value (kcal/100g sample)	16.1±0.21	152.3±0.43

Values are Means ±S.E.M of triplicate determinations

Table 2. Amino acids composition of *B. guianensis*

Amino acids.	Amount. (mg/100 g)	% composition
Glycine	5.07759	5.89
Alanine	4.36527	5.06
Serine	4.02241	4.66
Proline	5.00194	5.80
Valine*	5.10672	5.92
Threonine*	4.36424	5.10
Isoleucine*	4.82578	5.59
Leucine*	4.91224	5.70
Aspartate	5.41920	6.28
Lysine*	3.40752	3.95
Methionine*	1.00478	1.16
Glutamate	17.41592	20.19
Phenylalanine*	4.86845	5.64
Histidine*	3.86093	4.48
Arginine	8.10034	9.39
Tyrosine	2.21431	2.57
Tryptophan*	1.17532	1.36
Cysteine	1.11802	1.30
Total	86.26099	
TEAA		48.29
TNEAA		51.71
TSCAA		2.5
TAAA		9.57

* Essential amino acid; TEAA= Total essential amino acid; TNEAA= Total non-essential amino acid; TSCAA=Total sulphur-containing amino acid; TAAA,=Total aromatic amino acid

Table 3. Comparison of essential amino acid composition of *B. guianensis* with world health organization recommended daily amount for essential amino acid

Amino acid	Conc. in sample (mg/Kg)	%DV	mg/ kg bw FAO/WHO/UNU (2008)
Histidine	38.6	380.6	10
Isoleucine	48.3	241.5	20
Leucine	49.1	125.9	39
Lysine	34.1	113.7	30
Methionine+cysteine	10.0+11.1=(21.1)	140.7	10.4+4.1(total=15.5)
Phenylalanine+Tyrosine	48.7+11.7 (Total 60.4)	241.6	15+10 (total 25)
Threonine	43.6	290.7	15
Tryptophan	11.8	295	4.0
Valine	51.1	196.5	26

[24]; mg/ kg bw = mg/kg body weight

Table 4. Comparison of chemical scores of *B. guianensis* leaves with WHO reference protein pattern

	Human milk	whole fowl egg	A	B
Histidine	21	1.67	18.4	231
Isoleucine	55	5.0	8.77	96.5
Lysine	69	4.64	4.9	73.49
Methionine/Cystein	33	9.89	6.42	21.42
Phenylalanine/Tyrosine	8.15	7.53	17.3	94.29
Threonine	44	3.41	9.9	128
Tryptophan	17	4.0	6.9	16.0
Valine	55	6.02	9.2	84.8

Reference pattern mg/g protein amino acid score (%); A = *B. guianensis* compared with human milk; B = *B. guianensis* compared with fowl egg protein pattern; Values from FAO/WHO/UNU (2007) (25)

Table 5. Mineral composition of *B. guianensis*

Minerals	Amount (mg/L)	% DV	Compared with WHO RDA FAO/WHO/UNU [22]
Sodium	213.6	14.24	1500mg
Calcium	1926	192.6	1000mg
Magnesium	3636	363.6	1000mg
Copper	0.4572	50.8	900 µg
Manganese	0.9465	52.58	1.8mg
Potassium	5385	114.57	4700mg
Phosphorus	795.5	113.64	700mg
Selenium	0.0984	178.9	55 µg
Cobalt	0.0095	47.5	Less than 20µg
Iron	57.36	318.7	18mg
Total	12,014.86		15

Table 6. Vitamins composition of *B. guianensis*

Vitamins	Amount. (mg/100g)	%DV	Compared with WHO RDA (22)
Vitamin A	0.012	0.003	400mg
Vitamin B ₁	0.001	0.07	1.4mg
Vitamin B ₂	0.070	5.83	1.2mg
Vitamin B ₃	0.775	3.75	20mg
Vitamin B ₅	0.131	10.9	1.2mg
Vitamin B ₆	0.179	11.2	1.6mg
Vitamin B ₉	0.639	160	400µg
Vitamin C	19.0	21.1	90mg
Vitamin E	0.623	4.15	15mg
Vitamin K	0.208	173	120 µg

WHO RDA: World Health Organization Required Daily Allowance. Percent daily value (%DV) is based on the reference caloric intake of 2,000 caloric for adults and children aged 4 years and above. The daily values may be higher or lower based on individual needs.(23)

3.5 Discussion

3.5.1 Proximate composition of *B. guianensis*

The proximate analysis of the leaves of *B. guianensis* was carried out for both fresh and dried sample. It is discernible from the data shown in Table 1 that a higher moisture level in the leaves resulted in a concomitant decrease in dry matter content.

B. guianensis has a high moisture content greater than that earlier reported for *Talinum triangule*, *Telferia occidentalis* [26,27] *P. tuberregium scelerotia* [28]. *A. hybridus*, *C. pepo*, *G. Africana* [29] *G. latifolium*, *P. guinense*, *X. aethiopica*, *M. myristica*, *T. tetrapetra*, *A. sativum* [30] but slightly lower than that of *Pennisetum purpureum* [31] and *Tridax procumbens* [32]. Onyeike et al. had reported

that fruits and vegetables contain as high as 85% water [33]. The moisture content of food material is a measure of the index of its water activity [34] and this is employed to check the stability and susceptibility of food to microbial contamination [35]. A higher moisture content usually provides an adequate aid for the activity of water soluble enzymes and co-enzymes which are needed for the proper metabolic activities of leafy vegetables. The effect of this is that the leaf will have lower shelf life than, *Pennisetum purpureum* and *Tridax procumbens*. This implies that the leaves of *B. guianensis* may not be stored for a long time.

B. guianensis has a very low total carbohydrate content less than those earlier reported for *P. tuberegium sclerotia* [28] *G. latifolium*, *P. guineense*, *X. aethiopica*, *T. tetrapetra* [30], *Sansevieria liberica* Gerome and Labroy [36] *A. hybridus*, *C. pepo*, *G. Africana* [29] *Pennisetum purpureum* [31] *A. sativum* [30]. This implies that the leaves had to be supplemented with other diet in order to meet the energy demand of the body. Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissue [37].

B. guianensis has a high content of protein (28% dry weight). The crude protein content of this leaf is greater than those reported for *C. pepo*, *G. Africana* [29]. *Tridax procumbens*, Ikewuchi [32], *Pennisetum purpureum* [31] *Psychotria sp.*, *C. aconitifolius* and *T. occidentalis* [27]. But lower than *P. P.tuberegium sclerotia* [28]. The value of protein in *B. guianensis* is greater than the recommended amount [3.3%] by the United State Dietary Association Nutrient Database [38]. The protein value of *B.guianensis* as observed in this study makes it a better source of vegetable protein over the above mentioned vegetables as well as those earlier reported for raw cocoyam leaf, (3.4%) and cooked cocoyam leaf (2.1%), *Amaranthus hybridus* (6.1%) and *Moringa oleifera* [39]. This indicate that the leaves as rich source of protein (most especially in the dry state) are suitable for consumption for building body cells and tissues, enhanced enzymatic activity, and proper growth as well as mediate cell responses [36]. Inclusion of *B. guianensis* in our diet will therefore boost protein levels which provide immense benefits which among others include formation and synthesis of enzymes and hormones, maintain immune function just to mention but a few.

Brillantaissia guianensis has a considerable high amount of crude fibre (36% dry wet) greater than

those reported for other Nigerian vegetables like *P.tuberegium sclerotia* (3.2%) [28] *Psychotria sp* (1.46%), *C. aconitifolius*, (4.3%) *T. occidentalis* (5.2%) [27], *A. hybridus*, (19.60%), *C. pepo* (15.20%) [29], *Tridax procumbens* (6.13%) [32] 'oha' (*Pterocarpous soyauxii* (13.1%), 'Nturukpa' *Pterocarpous santhalinoides* (10.55%,) [39] 'okazi' *Gnetum Africanum*, (24.6%) but lower than *G. Africana* (43.6%) [29]. Epidemiological evidences suggest that increased fiber consumption may contribute to a reduction in the incidence of diseases including colon cancer, coronary heart diseases, diabetes mellitus, high blood pressure, obesity, and various digestive disorders [39,40]. Dietary fibre has been associated with the alteration of the colonic environment that protect against colorectal diseases. Fibre may also provide protection by increasing faecal bulk, which dilutes the increased bile acid concentration that occur with a high fat diet [39,41]. Fibre also adds to the food and prevents the intake of excess starchy food and may, therefore protect against metabolic conditions such as hypercholesterolemia and diabetes mellitus. This also collaborate the use of this plant by the locals in the treatment and management of diabetes mellitus in Ohafia in Abia State of Nigeria and in the management of cardiovascular disease in central province of Cameroun. This therefore suggest derivable benefit from the consumption of *B. guianensis*.

Ash content of *B. guianensis* was at the moderate level. Ash content can be seen as an index of mineral content in a food after all the decarbonation. The value obtained from this experimental sample was greater than that of *Sansevieria Liberia gerome and labroy* leaves [36] *Talinum traiangulare*, *Moringa oleifera* [42] *Psychotria sp.*, *C. aconitifolus*, *T. occidentalis* [27] *A. hybridus*, *C. pepo*, *G. Africana* [29]. Ukam had noted that the greater the ash content of a sample, the greater the nutritional value and quality [43]. The increase in ash content of the dried sample suggests that it is a good source of mineral elements. *B. guianensis* thus could be used in preparing different Nigerian dishes due to its high nutritional value.

Due to the general low level of crude fat in the leaf, their consumption in large quantity is a good habit and may be recommended to individuals suffering from obesity who would desire to reduce weight.

Amino acids: The leaves of *B. guianensis* contain a relatively higher amount of non-

essential amino acids (51.75%) than the essential amino acid (48.29%). It has a higher total aromatic amino acid of (9.44%) than the total sulphur containing amino acid which is 2.40%. *B. guianensis* is rich in essential amino acid such as valine, threonine, isoleucine, leucine, phenylalanine, histidine and arginine that can meet the minimum daily requirement for adult (Table 3) [24,45]. In comparison to the WHO reference protein pattern [22,25] there is no limiting amino acid in the leaves of *B. guianensis*. The essential amino acid present can meet the minimum daily requirement.

The most prominent essential amino acid in the leaf is Arginine and is higher than that reported for *G. latifolium* and *Verononia amydalina* [46]. In comparison to the egg and human milk protein reference, the green leaves score higher than those previously reported for *G. latifolium* and *Verononia Amydalina* [46].

Minerals: The leaves of *B. guianensis* have a high percentage of macro minerals. The leaves have greater content of magnesium and potassium than those earlier reported for most plants such as *Ficus capensis*, *Solanum nigrum*, *Moringa oleifera*, *Solanum aethiopicum*, *Evis discohus acantifolius*, but less calcium, copper, manganese, iron and selenium [47]. From this result, one can infer that *B. guianensis* are good sources of minerals which can help in the maintenance of acid-base balance of the body tissues. Calcium plays a major role in sustaining strong bones and in the contraction and relaxation of muscle, synaptic transmission, blood clotting as well as in the absorption of vitamin B₁₂. The high content of calcium (21.13 mg/100 mL) in *B. guianensis* suggests its therapeutic potential in hypocalcaemic states in diseases such as osteoporosis. The calcium, magnesium, potassium, iron, selenium and phosphorus content of *B. guianensis* is high enough to meet the FAO/WHO recommended dietary allowance [23]. Potassium is the most prominent intracellular cation which plays a major role in acid-base balance, muscle contraction, regulation of osmotic pressure as well as Na⁺/K⁺ATPase pump [48].

The potassium, magnesium, calcium and phosphorus content of the leaves are greater than those reported by Iheanacho et al. for *C. pepo*, *A. hybridus*, *G. africanum* while the iron content of the leaves was lower [28]. Iron is a major component of the heme of haemoglobin (Hb), Cytochrome and myoglobin

[48]. Iron has also been shown to be an important trace element which plays numerous biochemical roles in the body, including oxygen binding to haemoglobin. The leaf therefore is recommended for anaemic patients. Magnesium is a part of enzyme involved in urea formation, pyruvate metabolism and galacto-transferase of cardiac tissue biosynthesis [48]. From the result, it has been shown that consumption of *B. guianensis* can serve as an excellent source of minerals for human nutrition.

Vitamins: *B. guianensis* is rich in ascorbic acid and has moderate amount of vitamin B₃ and vitamin E. The vitamin C concentration is higher than the concentration previously reported for stable vegetables such as *Ficus capensis*, *Solanum melangena*, *Muccan prurein solanum*, *Macrocarpon*, *Solanum nigrum*, *Moringa oleifera*, *solanium ethiopicum*, *Gridoscolu acantifolus* [47] but lower than the ones reported for fresh and dried *psychotria sp.*, *C. acantifolius* and *T. occidentalis* [30]. Vitamin A is essential in human diet for normal vision, gene expression and growth and immune function by its ability to maintain epithelial cell functions [49]. Vitamin B₁ niacin, B₂ riboflavin, B₃, thiamine and pyridoxine B₆, play important role in nutrient metabolism as they are potent anti-oxidants which enhance the transport and uptake of non-heme iron in the mucosa, facilitate the synthesis of cortisol as well as the radiation of folic acid intermediates. The deficiency symptoms of vitamin C include fragility of blood capillaries, scurvy with swelling of the joints and gums, loosening of the teeth and haemorrhages of the skin and mucus membrane. Vitamin C as an anti-oxidant helps to protect the body against cancer and other degenerative diseases such as type [11] diabetes mellitus and arthritis [50,51]. Additionally, ascorbic acid may potentially act as an anti-cancer agent [52].

Vitamin E is a powerful antioxidant that helps to protect the cells of the body against free radical damage. It is also very important in the formation and function of the red blood corpuscles and muscles [53]. It is an integral part of cellular membrane whose main role is to defend the cell against oxidation. Vitamin E is the first line of defense against lipid peroxidation in the cells.

4. CONCLUSION

The present study has shown that the leaves of *B. guianensis* contained an appreciable amount of vital nutrients that can adequately meet with World Health organization's required daily

allowance. It is believed that these results will help stimulate the consumption or utilization of this plant in sufficient amount thereby contributing greatly towards meeting human nutrient requirement for normal growth and adequate protection against diseases arising from malnutrition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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