Assessment of Mineral and Antinutritional Qualities of *Ceiba Pentandra* Succulent and Matured Leaves

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ABSTRACT

Background: *Food insecurity remains a major challenge in Nigeria, assessing mineral and antinutritional qualities of Ceiba could ensure food security and improve people's diet.*

Objectives: The study assessed mineral and antinutritional qualities of succulent and matured leaves of two Ceiba accessions.

Materials and methods*: Succulent and matured leaves of Ceiba were collected from Ayede and Unosi in Kogi State, Nigeria and investigated for minerals and anti-nutrients using standard analytical procedures. The experiment was a 2x2 factorial in completely randomized design (CRD) with three replicates. Data collected were subjected to the analysis of variance in CRD using GENSTAT statistical software.*

Results: *Unosi accession significantly ($p<0.05$) had higher potassium (42.9 mg/100g). Phosphorus (72.2 mg/100g) and zinc (0.764 mg/100g) were more in Ayede. Matured leaves possessed higher calcium (21.22 mg/100g) and magnesium (62.81 mg/100g). Succulent leaves had more phosphorus (75.5 mg/100g). Genotype x traits biplot analysis revealed that matured leaves from Ayede had higher calcium. Iron, phosphorus and zinc were more in succulent leaves from Ayede. Matured leaves from Unosi had higher magnesium. Succulent leaves from Unosi contained higher potassium. Higher oxalate (172.5 mg/100g) and phytate (3.90 mg/100g) were attributed to matured leaves. Biplot analysis revealed that all the anti-nutrients were higher in matured leaves from Ayede.*

Conclusion: *Ayede accession is a better option for the consumers and for genetic improvement since the anti-nutrient content can be reduced during the cooking process. Higher anti-nutrients in matured leaves and higher mineral values in succulent leaves of Ceiba suggests the consumption of the succulent leaves.*

Keywords: *Ceiba pentandra*, Accession, Minerals, Antinutrients

INTRODUCTION

Ceiba pentandra is a tropical tree belonging to the family Malvaceae. It is a plant that grows in the wild. The English name for the tree is Kapok or white Silk-Cotton tree. In Nigeria it is called Araba in Yoruba, Akpu-ogwu in Igbo and Rimi in Hausa (1, 2, 3). Kapok tree is one of the tallest trees in the tropical forest reaching as high as 60 m in rainforests of West Africa (4). Their thick columnar trunks often have large buttresses (5). The trunk and many of the larger branches are often crowded with large simple thorns. The palmate leaves are composed of 5 to 9 leaflets, each up to 20 cm long (4). Ceiba fruits are large ellipsoid capsules up to 20 cm long, with 5 woody valves that split open to reveal abundant fluff, or kapok in which the many small black-brown seeds are embedded (6).

Kapok tree is a multipurpose plant. Vegetable oil can be pressed from kapok seeds which is used for soap, bio fuel, paint preparation and can also be used as fertilizer (7). *Ceiba pentandra* is a good source of fibre and timber. Kapok fibre is used for stuffing cushions, pillows and mattresses, and for insulation, absorbent material and tinder. The wood is mostly used in plywood manufacturing and in making canoes. It is also used for lightweight furniture, musical instruments, mortals, carvings and similar items (7).

In parts of Kogi State, *Ceiba pentandra* leaves are among the leafy vegetables that contributes to the rural farmer's economy. The young leaves are used for soup in form of slurry sauce comparable to Okra used for eating starchy balls made from cassava, yam and millet (8, 9). The leaves are also dried and made into powder which is used to prepare sauce during the dry season. In Senegal, freshly pounded leaves are steeped in water which is drunk for general fatigue and lumbago. In many countries in Africa, the bark and the stem are taken for diarrhea, stomach complaints, hernia, asthma and sometimes toothache (9). Chemical analysis has shown that the leaves of *Ceiba pentandra* contain minerals and anti-nutrients. Shahin et al. (10) reported 153.66 mg/100g of potassium, 177.0 mg/100g of calcium, 48.15 mg/100g of magnesium, 1.54 mg/100g of iron, and 27.09 mg/100g of zinc. Friday *et al*. (9) reported that it cont-ains oxalate (0.10 mg/100g), phenol (173.94 mg/100g), saponin (1.55 mg/100g) and tannin (0.48 mg/100g).

There were reports of previous studies on accession and leaf age. Ndubuaku *et al*. (11) reported that there were no significant differences in the chemical compositions of the leaves of plants collected from the different locations except sodium and zinc contents. Ibrahim *et al*. (12) reported higher calcium (82 ppm) and phosphorus (39 ppm) in matured leaves but higher potassium (18.0 ppm) in young leaves of *Piliostigma thonningii*. Ojewuyi *et al*. (13) who worked on young and mature leaves of *Polyalthia longifolia Sonn* reported higher tannin of 3.91 ppm and phenol of 0.34 ppm in young leaves.

Despite the usefulness of this vegetable, it consumption is low due to inadequate information to create awareness regarding the nutritional potentials of the leaves. Information from the nutritional and anti-nutritional analysis of this leafy vegetable would provide better understanding of it nutritional importance that can help in addressing food crises. Therefore, this study was undertaken with a view to determine mineral and anti-nutrient components of succulent and matured leaves of *Ceiba pentandra* as influenced by accession in order to provide nutritional information that can encourage cultivation of the nutrient dense alternative to prevent it from going into extinction and increase its demand, thereby enhancing social and economic status of the farmers as well as the nutritional and health status of the consumers.

Materials and Methods

Samples Collection

Samples of fresh (succulent and matured) leaves of *Ceiba pentandra* were collected from Ayede in Kabba-Bunu Local Government Area and Unosi in Ajaokuta Local Government Area of Kogi State. First to fourth leaf from the shoot-tip and older leaves from the base were used for laboratory analyses. The succulent leaves were small, soft, delicate to the touch and light green in colour while the matured leaves were hard when touched and dark green. The leaves were named according to location of collection and the triplicate samples of the leaves were packed in paper envelops and taken to Simuch Scientific Analytical Laboratory, Nsukka for mineral and anti-nutrient analysis. The study was carried out as 2x2 factorial experiment in completely randomized design (CRD).

Succulent leaves of *Ceiba pentandra*

Mature leaves of *Ceiba pentandra*

Ceiba pentandra plant

Analysis of Minerals

The official method of AOAC (14) was adopted for the mineral analysis of the samples. Two gram of each ground sample was weighed into a silica dish, then placed in a muffle furnace and heated at 600 ^{0}C for three hours, allowed to cool in a desiccator and weighed. The samples were dissolved with HCl and prepared for reading using atomic absorption spectrometry (AAS). Calcium, iron, potassium, magnesium and zinc were determined using atomic absorption spectrometer (AA-7000) and absorbance read at 422.7 kk-nm, 248.3 kk-nm, 766.5 kk-nm, 285.2 kk-nm and 213.9 kk-nm wavelength respectively. Vanado-Molybdate Calorimetric method was used to determine phosphorus using spectrophotometer (752P) at a wavelength of 92.25 nm.

Anti-nutrients analysis

Anti-nutrient contents were analyzed using the methods described by Harborne (15). Determination of cyanide was done by weighing 0.2 g fresh ground sample into a 100 ml conical flask. Five ml of water was added, shaken, covered and allowed to stand for 30 minutes. Five ml of the sample extract was pipetted into 50 ml volumetric flask, then 10ml of linamarase added and incubated for 10 minutes at room temperature. The volume of the incubation mixture was made up to 45 ml with water. Five ml of sodium picrate was added and incubated in a boiling water bath for 5 minutes. Cooling was done at room temperature and the absorbance read at 520 nm. Two gram of the sample was put into a 50 ml conical flask to determine oxalate. Twenty ml of 30% HCl was added and allowed to stand for 5 minutes. Four gram of ammonium sulphate was added, shaken gently to dissolve and allowed to settle. The supernatant was decanted into a 25 ml volumetric flask and made up the volume with 30 % HCl, then transferred to 50 ml volumetric flask and equal volume of diethyl ether added, then adjusted to pH 7.0 with either NH_4OH (Ammonium hydroxide). Centrifuged at 3000 rpm for 10 minutes and decanted into a 250 ml conical flask and absorbance of the end product read at 490 nm using Spectrophotometer (752P). Phenol was determined by weighing 0.1 g of dried sample extracted with 25 ml of ethanol, then filtered into 100 ml volumetric flask. Extraction process was repeated three times and the volume made up with ethanol. 10ml of the above solution was diluted to 100 ml with ethanol and the absorbance read at 425 nm using Spectrophotometer (752P). Phytate was determined by weighing 0.5 g of sample into a 500 ml round bottomed flask and extracted with 199 ml of 2.4 % HCl for 1 hour at room temperature, then decanted and filtered. Five milliliter of the filtrate was Pipetted and diluted to 25ml with water. Fifteen milliliter of 0.7 m sodium chloride was added and absorbance read at 520 nm using Spectrophotometer (752P). Saponin was determined by weighing 0.1 g of the processed sample into a test tube and 5 ml of distilled water added, boiled for 5 minutes then filtered while hot. One milliliter of the filtrate was pipetted into a test tube and 10ml of distilled water added. The mixture was shaken vigorously; the formation of a stable foaming froth was observed. The absorbance of the solution was measured at 62nm using Spectrophotometer (752P). Tannin was discovered by weighing 2 g of the sample into 50ml conical flask, 10ml of 2m HCl was added and shaken. Twenty milliliter water was added and mixed. The content was filtered into a 5ml volumetric flask and made up to 50ml. Five milliliter of the solution was pipetted into a test tube and 5ml of water was poured as control into another test tube. Three milliliter of $FeCl_3$ in 0.1 m HCl and 3 ml of 0.008 $(K_3CCN)_6$) check. was added to each test tube, respectively. Allowed to stand for 30 seconds and read absorbance at 720 nm using Spectrophotometer (752P).

Statistical analysis

Data collected were subjected to the analysis of variance (ANOVA) in completely randomized design (CRD) using GENSTAT Discovery edition 3 Release 7.22 DE (16). Significant treatment means were compared using least significant difference (LSD) at 5% level of probability. Genotype plus genotype by environment interaction (GGE) biplot was used to illustrate the combined effect of accession and leaf age on mineral and anti-nutrient compositions of Ceiba leaves.

Results

Main effect of accession on mineral composition of *Ceiba pentandra* leaves is presented in Table 1. Potassium, phosphorus and zinc were significantly ($p \leq 0.05$) influenced by accession but calcium, iron and magnesium were statistically the same in both locations. Concentration of potassium (42.90 mg/100g) was higher in *Ceiba pentandram* leave sourced from Unosi. Conversely, phosphorus and zinc were higher in the leaves of accession collected from Ayede with respective values of 72.20 and 0.76 mg/100g.

Table 2 shows the main effect of leaf age on mineral composition of *Ceiba pentandra* leaves. Leaf age had significant ($p \leq 0.05$) influence on calcium, magnesium and phosphorus but showed no significant difference on iron, potassium and zinc. Higher values for calcium (21.22 mg/100g) and magnesium (62.81 mg/100g) were obtained in matured leaves. However, higher phosphorus content (78.50 mg/100g) was obtained in succulent leaves.

Figure 1 shows the combined effects of accessions and leaf age on mineral composition of *Ceiba pentandra* leaves.
The biplot revealed that calcium was more pronounced in matured leaves from Ayede. Succulent leaves obtained from Ayede had higher values for iron, phosphorus and zinc. Also, concentration of magnesium was higher in matured leaves from Unosi. Concerning potassium, succulent leaves sourced from Unosi registered higher value.

Table 1: Main effect of accession on mineral composition (mg/100g) of *Ceiba pentandra* leaves

Accession	Ca	Fe	K	Mg	P	Zn
Ayede	15.75	18.88	10.70	61.15	72.20	0.76
Unosi	15.40	18.85	42.90	62.44	56.60	0.37
	3.33	4.86	27.04*	1.69	12.33*	0.27*

Ca- calcium, Fe- iron, K= potassium, Mg-magnesium, P- phosphorus and Zn- zinc
*- significant at $P < 0.05$.

Table 2: Main effect of leaf age on mineral composition (mg/100g) of *Ceiba pentandra* leaves

Leaf age	Ca	Fe	K	Mg	P	Zn
Matured	21.22	18.68	17.90	62.81	50.40	0.56
Succulent	9.93	19.05	35.80	60.79	78.50	0.57
LSD (0.05)	3.33*	4.86	27.04	1.69*	12.33*	0.27

Ca- calcium, Fe- iron, K= potassium, Mg-magnesium, P- phosphorus and Zn- zinc
*- significant at $P < 0.05$.

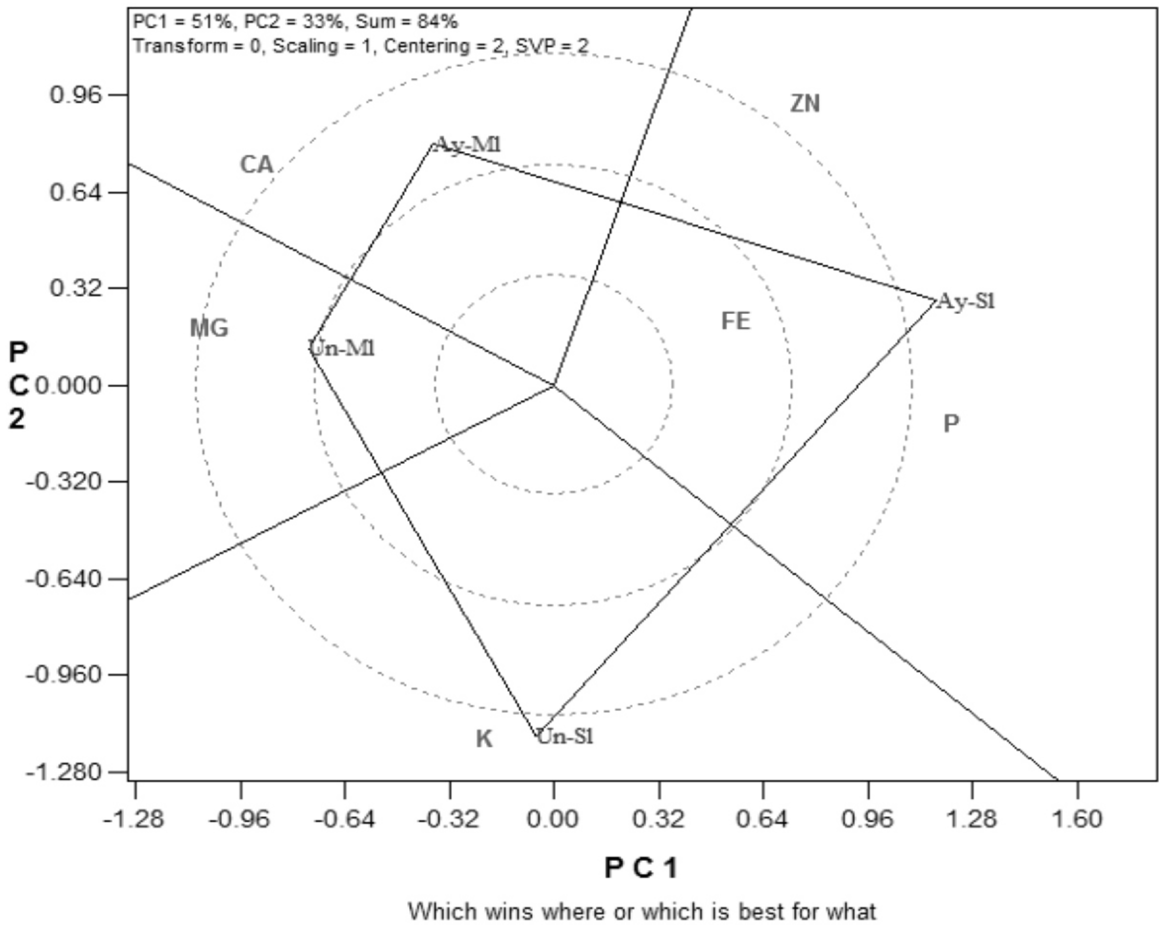

Figure 1

Figure 1: GGE biplot showing combined effects of accessions and leaf age on mineral composition of *Ceiba pentandra* leaves. Ca= calcium, Fe= Iron, K= Potassium, Mg= magnesium, P= Phosphorus and Zn= Zinc. Ay-Ml= Ayede (Matured leaves), Ay-Sl = Ayede (succulent leaves), Un-Ml= Unosi (Matured leaves) and Un-Sl= Unosi (succulent leaves).

Main effect of accession on anti-nutrient contents of *Ceiba pentandra* leaves is shown in Table 3. Accession did not influence all the anti-nutrient traits. However, leaf sourced from Ayede had the higher cyanide, phenol, phytate, saponin and tannin values of 4.44, 19.70, 3.49, 0.26 and 4.73 mg/100g, respectively. Only oxalate value was higher in Unosi accession (145.40 mg/100g).

Table 4 presents the main effect of leaf age on anti-nutrient contents of *Ceiba pentandra* leaves. Leaf age had significant ($p \leq 0.05$) effect on oxalate and phytate but cyanide, phenol, saponin and tannin did not differ significantly. Oxalate and phytate were higher in matured leaves with the values of 172.50 and 3.90 mg/100g, respectively.

Table 3: Main effect of accession on anti-nutrient contents (mg/100g) of *Ceiba pentandra* leaves

Accession	Cyanide	Oxalate	Phenol	Phytate	Saponin	Tannin
Ayede	4.44	134.20	19.70	3.49	0.26	4.73
Unosi	3.46	145.40	17.20	3.01	0.18	4.16
LSD (0.05)	2.01	42.34	8.04	0.83	0.14	1.27

Table 4: Main effect of leaf age on anti-nutrient contents (mg/100g) of *Ceiba pentandra* leaves

Leaf age	Cyanide	Oxalate	Phenol	Phytate	Saponin	Tannin
Matured	3.94	172.50	18.70	3.90	0.23	4.33
Succulent	3.96	107.10	18.20	2.60	0.19	4.55
LSD (0.05)	2.01	42.34*	8.04	0.83*	0.14	1.27

*- significant at $P < 0.05$

Figure 2 revealed the combined effects of accessions and leaf age on anti-nutrient contents of *Ceiba pentandra* leaves.
The biplot showed that cyanide, oxalate, phenol, phytate, saponin and tannin were generally higher in matured leaves from Ayede than others.

Discussion
The result revealed that the leaf of *Ceiba pentandra* of the two accessions evaluated were high in mineral contents. The values obtained for calcium, potassium magnesium, phosphorus and zinc in this study were lower than what was reported by Adepoju and Ugochukwu (8) who obtained 119.38 mg/100g of calcium, 183.40 mg/100g of potassium, 102.48 mg/100g of magnesium, 112.99 mg/100g of phosphorus and 1.30 mg/100g of zinc in *Ceiba pentandra* leaves from Imo State. Their iron value was; however, lower (3.63 mg/100g) when compared with the value obtained in this work. The potassium content recorded in Unosi and magnesium values obtained in both locations were higher than (23.1 and 24.78 mg/100g) reported by Osuntokun *et al.* (7) in Ceiba leaves from Ondo State but iron value (20.34 mg/100g) was comparable to the values recorded in this study. Shashin *et al.* (10) reported higher calcium

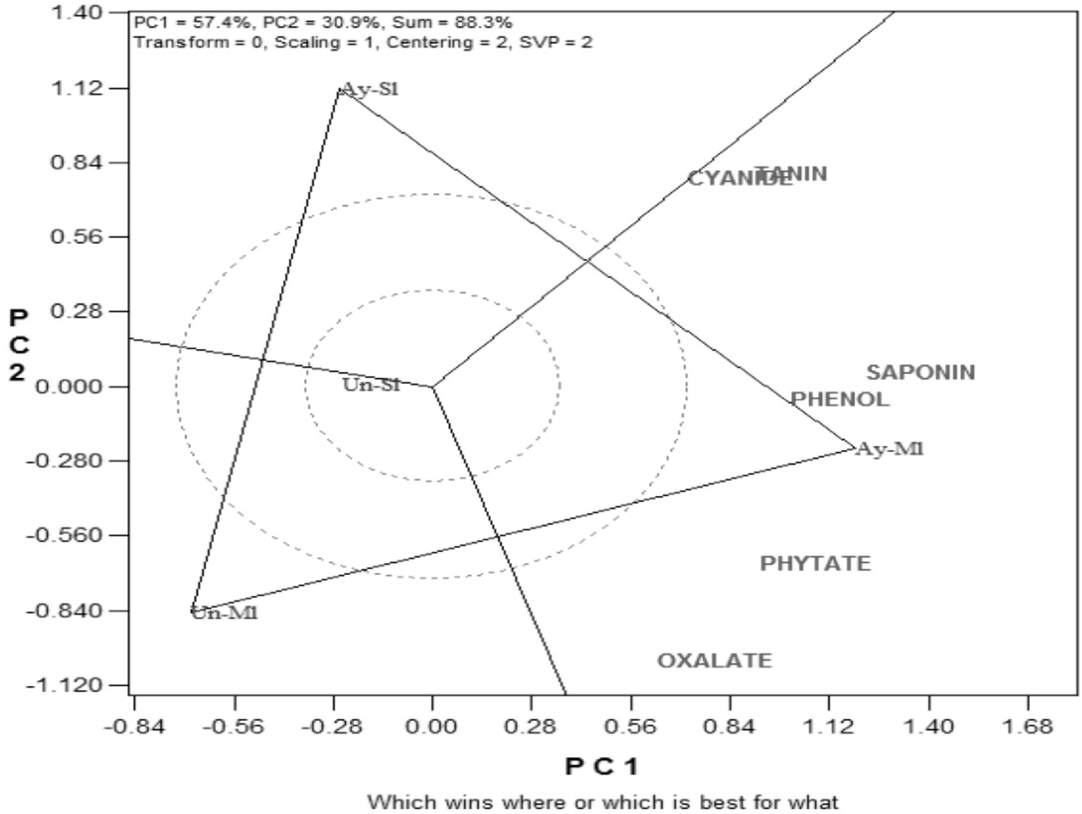

Figure 2: GGE biplot showing combined effects of accessions and leaf age on anti-nutrient contents of *Ceiba pentandra* leaves. Ay-Ml= Ayede (Matured leaves), Ay-Sl = Ayede (succulent leaves), Un-Ml= Unosi (Matured leaves) and Un-Sl= Unosi (succulent leaves).

(177.0 mg/g), potassium (153.66 mg/g), magnesium (48.15 mg/g) and zinc (27.09 mg/g) in Ceiba leaves from Bangladeshi while iron value (1.54 mg/g) was quite lower than the value recorded in this work. These minerals are required for normal functioning of the body. Calcium and phosphorus gives strength and rigidity to bones and teeth. Zinc is an essential trace element for protein and nucleic acid synthesis and normal body development (17). Magnesium is used by the body to help maintain muscles, nerves and bones. Iron is very important in formation of red blood cells. Phosphorus is essential to the fundamental process of metabolism in the body. Potassium is an essential nutrient to regulate blood pressure and has an essential role in protein and amino acid synthesis (18, 19). The variation observed in mineral contents may be due to genetic makeup and environmental differences. Differences in nutritive values may be attributed to differences in plant variety, climatic and geographical differences (20).

The mineral analysis of both matured and succulent leave samples in this study showed that they contained appreciable quantities of minerals with the matured leaves registering higher concentration of calcium and magnesium which is similar to those reported by Ojewuyi *et al*. (13) who reported higher calcium (89.18 mg/100g) and magnesium (27.55 mg/100g) values in mature leaves of *Polyalthia longifolia Sonn* from Kwara State. Ibrahim *et al*. (12) reported lower calcium (82 ppm) in matured leaves, lower potassium (18 ppm) value in succulent leaves and lower phosphorus value (39 ppm) was obtained in matured leaves of *Piliostigma thonnongii* from Niger State when compared with the result obtained in this present study. Ndubuaku *et al*. (11) reported lower values for iron (66.20 ppm), potassium (0.39 %) and phosphorus (74.90 ppm) in succulent leaves of *Moringa oleifera* from Nsukka compared with the values obtained in this study. Zinc content was higher in succulent leaves as obtained in this study; this result negates the findings of Ndubuaku *et al*. (11) who reported lower zinc value (2.98 ppm) in old leaves of moringa. The higher value for iron, potassium, phosphorus and zinc in succulent leaves than the matured leaves could suggest higher metabolic activities in the young leaves of *Ceiba pentandra*. Ndubuaku *et al*. (11) reported higher values for vitamins, proximate and chemical properties in the succulent leaves of moringa in Nsukka compared with the older ones which could be as a result of higher metabolic activities in the succulent leaves.

Phenol and tannin values obtained in this study were higher than (0.03 mg/100g and 0.81 mg/100g) reported by Raimi *et al*. (21) in leaves of *Ceiba pentandra* from South-western Nigeria. Osuntokun *et al*. (7) reported lower oxalate (8.51 mg/100g), phenol (3.49 mg/100g), and tannin (2.3 mg/100g) in Ceiba leaves from Ondo State when compared with the results obtained in the current study but phytate (12.33 mg/100g) and saponin (7.52 mg/100g) were higher than the values recorded in this work. Uraku and Nwankwo (22) who worked with *Murraya koenigii Linn* leaves from Ebonyi State, reported higher tannins (206.05 mg/100g) and lower saponins (0.03mg/100g) levels when compared with the values obtained in this study. The cyanide value obtained from the present study was higher than 0.09 mg/100g reported by Igile *et al*. (23) in leaves of *Vernonia calvaona* from Cross River State. The concentration of saponin content from Unosi accession and the succulent leaves were within the tolerable limits of 0.2 % reported by Codex (24), but oxalate, phenol, phytate and saponin values from Ayede accession and the hard leaves and tannin contents of succulent leaves of *Ceiba pentandra* from Unosi were above the tolerable limits of 5 % (25), 2 % (26), 9.22-5.72 % (27), 0.2 % (28) and 3.3 % (29), respectively. Since the leaves are not eaten raw, the anti-nutrient contents may be significantly reduced by heat during the cooking process. Boiling of plant parts in water reduced the poisonous effect of anti-nutrients and assists to increase their consumption (30, 31). Plant phenols may interfere with all stages of cancer process, potentially resulting in a reduction of cancer risk (32). Saponins are known to possess both antimicrobial (33) and anti-inflammatory activities (34). Studies have also reported the beneficial effects of saponins on blood cholesterol levels and stimulation of the immune system (35). The presence of tannins supports the use of this plant to treat bacterial infection of the bladder (36). The difference in the concentration of anti-nutrient content in this study may probably be as the result of the climatic conditions prevalent in the different locations. Variation in climatic conditions, soil nutrients, water quality (hydrogen potential, electrical conductivity), and agricultural activity could influence the production of phytochemicals, which in turn could affect the antioxidant activities (37).

Cyanide and tannin concentration recorded in this study were higher in succulent leaves while oxalate, phenol, phytate and saponin were higher in matured leaves. The higher concentration of the anti-nutrients in the mature leaves implies that mature leaves are better accumulators of these anti-nutrients. The cells of the mature leaves are usually tougher, larger and broader than those of the succulent ones. There was likely to be little or no mobility of the anti-nutrients from the older leaves to the succulent ones as the leaves were aging. The result of this work is in agreement with the findings of Ndubuaku *et al*. (11) who reported higher concentration of anti-nutrient contents in older leaves of Moringa in Nsukka. Ojewuyi *et al*. (13) reported higher tannin (3.91 ppm) and phenol values (0.34 ppm) in young leaves of *Polyalthia longifolia Sonn* from Kwara State.

Conclusion

Results from this study showed that some mineral and anti-nutrient constituents were present in *Ceiba pentandra* leaves. Noteworthy is that calcium, iron, phosphorus and zinc were more in leaves collected from Ayede. Therefore, this accession stands the chance of improving health and nutritional status of the people. It also gives room for selection and genetic improvement. The study also provides information that the matured leaves registered higher oxalate, phenol, phytate and saponin values than the succulent ones while succulent leaves had higher concentration of iron, potassium, phosphorus and zinc. The nutrient present in the succulent leaves will improve the health of the consumers. Therefore, there is need for the inclusion of *Ceiba pentandra* leaves as vegetable in everyday meal.

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References

1. Adeniji, I.T., Olomola, D.B. and Jegede, O.C. (2019) Seed Germination and Seedling Growth of *Ceiba Pentandra* (L) as Influenced by Different Soil Types in Ibadan, Southwest Nigeria. Journal of Research in Forestry, Wildlife & Environment, 11(3): 316-230.
2. Chaiarrekij, S., Apirakchaiskul, A., Suvarnakich, K. and Kiatkamjornwong, S. (2011) Kapok: Characteristics fibre as a potential pulp source for paper making. Bio resources, 7(1): 475-488.
3. Mojica, E.R.E., Merca, F.E., Micor, J.R.L. (2002) Fiber of kapok (*Ceiba pentandra*) as component of a metal sensor for lead in water samples. Philippine Journal of Crop Science, 27(2): 37-42.
4. Iroka, F. C., Okereke, C. N and Okeke, C. U. (2014) Comparative phytochemical and proximate analyses on *Ceiba pentandra* (L) Gaertn. and *Bombax buonopozense* (P) Beauv. International Journal of Herbal Medicine, 2(2): 162-167.
5. Woodward, C.L. (2010) The Ceiba Tree in Ceiba Foundation for Tropical Conservation 2009.
6. TROPICOS. (2009) Subordinate Taxa of ceiba Mission Botanical. Garden 13-10.
7. Osuntokun, O. T., Ayodele, A. O. and Adeoye, M. I. (2017) Assessment of antimicrobial and phytochemical properties of crude leaf and bark extracts of *Ceiba pentandra* on selected clinical isolates found in Nigerian teaching hospital. Journal of Bacteriology and Mycology, 4(1):17-23.
8. Adepoju, O.T. and Ugochukwu, I.C. (2019) Improving Vegetable Diversity and Micronutrient Intake of Nigerians Through Consumption of Lesser Known Silk Cotton (*Ceiba pentandra*) Leaf. International Journal of Nutrition, 4 (1): 19-30.
9. Friday, E.T., Omale, J., Olupinyo, O, Adah, G. (2011) Investigations on the nutritional and medicinal potentials of *Ceiba pentandra* leaf: A common vegetable. International Journal of Plant Physiology and Biochemistry, 3: 95-101.
10. Shahin, A., Husna, P.N., Shahal, A. and Md. Aminul, A. (2016) Proximate and Mineral Compositions of Leaves and Seeds of Bangladeshi Bombax Ceiba Linn. World Journal of Pharmaceutical Research, 5(7):1-13.
11. Ndubuaku,U.M., Uchenna, N.V., Baiyeri, K.P. and Ukonze, J. (2015) Anti-nutrient, vitamin and other phytochemical compositions of old and succulent moringa (*Moringa oleifera* Lam) leaves as influenced by poultry manure application. African Journal of Biotechnolog, 14(32): 2501-2509.
12. Ibrahim, I.L., Musah, M., Dagaci, M.Z., Mohammed, S.H., Baba, H.F., Umar, M.T. and Usman, R.L. (2019) Phytochemical

Screening, Mineral Determination and Antimicrobial Screening of the Leaves Extracts of *Piliostigma thonnongii* (Matured and Young) Leaves. African Journal of Agriculture and Food Science, 2(1): 15-27.

13. Ojewuyi, O.B., Ajiboye, T. O., Adebanjo, E. O., Balogun, A. and Mohammed, A.O. (2014) Proximate composition, phytochemical and mineral contents of young and mature *Polyalthia longifolia* Sonn. Leaves. *International Journal of Nutrition,* 4 (1): 19-30.
14. (AOAC) Association of Official Analytical Chemists. (2007) Official method of analysis. 18th ed. Washington D.C.
15. Harborne, J.B. (1973) Phytochemical methods: A *guide to modern techniques of plant analysis*. Chapman and Hall Ltd, London, 279.
16. Genstat. (2008) Genstat 7.22.0 Release 3 DE Discovery Edition, Lawes Agricultural Trust, Rothmanisted Experimental Station, UK.
17. Melaku, U. Clive E.W and Habtamon. (2004) Content of zinc, iron, calcium and their absorption inhibitor in foods commonly consumed in Ethiopia. Journal of Food Composition and Analysis, 18: 803-817.
18. Garrow, J.S, James, W.P.T. and Ralph, A. (2000) Human nutrition and Dietetics, 703. Churchill Living Stone, New York.
19. Mengel, K. (2009) *Potassium*. In: Handbook of Plant Nutrition (edited A.V. Barker and D.J. Pilbeam). CRC Press, New York., 93-105.
20. Egbekun, M.K and Ehieze, M.U. (1997) Proximate composition and functional properties of full- fat and defatted beniseed (*Sesamum indicum* L.) flour. Plant Foods for Human Nutrition, 51: 35-41. https://doi.org/10.1023/A:1007966103484
21. Raimi, M.M., Oyekanmi, A.M., and Farombi, A.G. (2014) Proximate and Phytochemical Composition of Leaves of *Ceiba pentandra, Manihot esculentus* and *Abelmoschus esculentus* in Southwestern Nigeria. Scientific Research Journal, 2(4): 30-34.
22. Uraku, A. J. and Nwankwo, V. O. (2015) Phytochemical and Nutritional Composition Analysis of *Murraya koenigii* Linn Leaves. Journal of Pharmaceutical Research International, 6(3): 174-180. https://doi.org/10.9734/BJPR/2015/15595.
23. Igile, G.O., Iwara, I.A., Mgbeje, B.I. A., Uboh, F.E. and Ebong, P.E. (2013) Phytochemical, Proximate and Nutrient Composition of *Vernonia calvaona* Hook (Asterecea): A Green-Leafy Vegetable in Nigeria. Journal of Food Research. 2(6): 1-11.
24. Codex Alimentarius. (2017) *Request for comments at step 3 on the proposed draft standard for quinoa.*Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme. Italy, Rome.
25. Caser, M. (2003) *Low oxalate diet*. University of Pittsburgh Medical Center Information for Patients. Pittsburgh, USA.
26. Michałowicz, J., and Duda, W. (2007) Phenols – Sources and Toxicity. Polish Journal of Environmental Study, 16 (3), 347-362.
27. Okon, E.U. and Akpanyung, E.O. (2005) Nutrition and anti-nutrition in selected brands of malt drinks produced in Nigeria, Pak. J. Nutr. 4: 352-355.
28. (AOAC) Association of Official Analytical Chemists. (2005) Official method of analysis. 17th ed. Washington D.C.
29. Elfadil, A.G., Sabahelkhier, M.K., Rayan, M.Y., Daa, M.O., Nagla, A.H., and Israa, S.B. (2013) Effect of Tannin and Plant Tannins on some Organs and Physic-Chemical Characters of Diabetic Wistar Rat.*International Journal of Advanced Research*, 1 (10): 165-170.
30. Dei, H.K., S.P. Rose and A.M. Mackenzie. (2007) Shea nut (*Vitellaria paradoxa*) meal as a feed ingredient for poultry. World's Poult. Sci. J, 63: 611-624.
31. Zafar, IK., Kafeel, A., Asma, Z., Humayun, B., Abrar, H., Zile, H., Hazoor, A.S., Muhammad, S., Ghulam, H., Ijaz, R.N., Nudrat Aisha, A., Muhammad, A., Fahim, A., Irfan, M., Vincenzo, T., Mariano, F. and Eugenio, C. (2015) Assessment of Poisonous and Anti-Nutritional Compounds in Wild Edible Forages Consumed by Ruminant Species. Journal of Environmental Science and Technology, 8: 91-101.
32. Hollman, P.C. (2001) Evidence for health

benefits of plant phenols: Local or systemic effects? J. Sci. Food Agric, 81: 842-852.

33. Soetan, K. O., Oyekunle, M. A., Aiyelaagbe, O. O. and Fafunso, M. A. (2006) Evaluation of the antimicrobial activity of saponins extract of Sorghum Bicolor L. Moench. Afr. J. Biotech, 5 (23): 2405-2407.
34. Hassan, H. S., Sule, M. I., Musa, A. M., Musa, K. Y., Abubakar, M. S. and Hassan, A. S. (2012) Anti-inflammatory activities of Crude Saponin Extracts from Five Nigerian Medicinal Plants. Afr. J Tradit Complement Altern Med, 9:250-255.
35. Cheeke, P. R. (2000) Actual and potential applications of Yucca schidigera and Quillaja saponaria saponins in human and animal nutrition. J Anim Sci, 77:1-10.
36. Avorn, J., Monane, M., Gurwitz, J.H., Glynn, R.J., Choodnovskiy, I., Lipsitz, L.A. (1994) Reduction of bacteriuria and pyuria after ingestion of cranberry juice JAMA, 271(10):751-4, http://dx.doi.org/10.1001/jama.1994.0351034 0041031.
37. Ali, G., Hawa Jaafar, Z. E., Mohamad, F.M.B., Mohd, H.R and Asmah, R. (2018) Assessment and comparison of phytochemical constituents and biological activities of bitter bean (Parkia speciosa Hassk.) collected from different locations in Malaysia. Chem Cent J, 12: 12