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## Nutritional qualities of Kapok (*Ceiba pentandra* L. Gaertn.) in response to fertilizer management

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### Abstract

*Ceiba pentandra* (L.) Gaertn, is a leafy vegetable that is under-utilized due to lack of information about the nutritional potential and agronomic practices. Minerals, vitamins, and protein content of succulent leaves of *C. pentandra* plants grown under different fertilizer rates (Control (No fertilizer), 5 t ha<sup>-1</sup> of poultry manure (PM) + 200 kg ha<sup>-1</sup> of NPK, 10 t ha<sup>-1</sup> of PM, 20 t ha<sup>-1</sup> of PM, 450 kg ha<sup>-1</sup> of NPK, and 20 t ha<sup>-1</sup> of PM + 100 kg ha<sup>-1</sup> of NPK) in the Department of Crop Science Garden, University of Nigeria, Nsukka were evaluated using standard analytical procedures in a replicated trial. Analysis of variance indicated a non-significant effect of fertilizer rates on vitamin contents assessed. Protein and the minerals evaluated showed non-significant response to fertilizer except zinc and calcium. Highest concentration of zinc (0.46 mg/100g) was attributed to 20 t ha<sup>-1</sup> of PM which was statistically similar to 0.43 and 0.42 mg/100g obtained from leaves of plants grown without fertilizer and 5 t ha<sup>-1</sup> of PM + 200 kg ha<sup>-1</sup> of NPK, respectively. Soil amendment at 5 t ha<sup>-1</sup> of PM + 200 kg ha<sup>-1</sup> of NPK resulted in high accumulation of calcium (145.00 mg/100g). Conclusively, application of 20 t ha<sup>-1</sup> of PM or 5 t ha<sup>-1</sup> of PM + 200 kg ha<sup>-1</sup> of NPK may be appropriate for growing *C. pentandra*. The study established that *C. pentandra* can be brought under regular cultivation culture without compromising the nutritional quality.

**Keywords:** *Ceiba pentandra*; fertilizer rates; nutritional quality; leafy vegetable; domestication

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## INTRODUCTION

*Ceiba pentandra* (L.) Gaertn. is an under-utilized indigenous plant species usually found in the wild, it belongs to Malvaceae family. The matured tree can reach 56 m in height with a girth of 10 m or more, it has a long cylindrical and huge buttresses of 8 m height and wide spreading (Friday *et al.*, 2020). The trunk and larger branches are often crowded and armed with conical spines. It has palmate leaves of about 5 to 9 leaflets, each up to 20 cm long (Osuntokun *et al.*, 2017). It is known as Araba in Yoruba, Akpu-Ogwu in Igbo, Rimi in Hausa and Bamtami in Fulani.

In Nigeria, *C. pentandra* is under-utilized, the leafy vegetable is known in local communities especially in Kogi State. The rural people cherish the leaf which is harvested, processed into powder and used to make delicious soup known as 'Kuka'. Friday *et al.* (2020) reported that dried leaf made into powder is used in preparing soup during the dry season. The succulent leaves can be boiled and made into soup comparable to Okra which is served with starchy balls made from cassava, yam and millet. Ethnobotanical evidences established that mashed leaves of the plant can be applied on tumors as dressing (Burkill and Dalziel, 1997; Kuruvilla and Anilkumar, 2018). The plant extract is also employed in treating eye and skin infections, dysentery, diabetes, arthritis, insect bite, diarrhea, bronchitis and chronic fever (Elumalai *et al.*, 2012). According to Alagawadi and Shah (2011), pharmacological studies attest to the anti-inflammatory properties of the plant parts. In addition, it possesses hepatoprotective (Bairwa *et al.*, 2010) and antiulcerogenic compounds (Anosike *et al.*, 2014).

The oil extracted from the seed has some potential as a bio fuel and it can also be used in paint preparation. The plant is a good source of fibre and timber (Osuntokun *et al.*, 2017). The floss from the fruit can be used for making mattresses, pillows, absorbent materials and tinder (Adeniji *et al.*, 2019). Several studies have shown that *C. pentandra* leaves contained minerals and vitamins. Shahin *et al.* (2016) 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. According to Adepoju and Ugochukwu (2019), *C. pentandra* leaves contain

vitamin B<sub>2</sub> (0.19 mg/100g) and B<sub>12</sub> (0.24 mg/100g). Friday *et al.* (2020) reported that *C. pentandra* possessed vitamin C (4.91 mg/100g).

Increase in dietary diseases and malnutrition ravaging most developing countries like Nigeria has been linked to nutritional deficiencies such as minerals and vitamins (Stevens *et al.*, 2021). Balanced and healthy diet can be ensured by consuming leafy vegetables as sources of minerals and vitamins accompanied with staple food. Vegetables have the potential to improve the diet of the people and reduce the risk of developing cancer, cardiovascular and other chronic diseases (Umakanta *et al.*, 2020). Despite the enormous benefits of *Ceiba pentandra*, it is under-utilized and the crop has not been brought under regular cultivation culture like the other indigenous plant species in Nigeria as a result of inadequate knowledge of its nutritional value, soil and fertilizer requirements, germination, agronomic practices and pests. The quality of farm produce is a function of the growing environment in which soil fertility management is a major determinant. Soil fertility could be enhanced using organic or inorganic fertilizers and could be integrated (Aba *et al.*, 2020). Therefore, investigating into this indigenous crop can provide evidence-based information that can encourage the domestication of this plant to remedy food security challenge, improve peoples' diet and prevent the crop from going into extinction. There is, therefore, the need to examine response of *C. pentandra* to different fertilizers especially with respect to the nutritional contents of the leaves. The aim of this study was to determine the leaf nutritional qualities of *C. pentandra* in response to different fertilizer management.

## MATERIALS AND METHODS

### Location of the Experiment

The field experiment was carried out at the Department of Crop Science teaching and research farm of University of Nigeria, Nsukka (07 ° 29' N, 06 ° 51' E and 400 m above sea level), Enugu State, Nigeria. Succulent leaves harvested at ten months after transplanting were analyzed for minerals, vitamins and protein content at Simuch Scientific Analytical Laboratory, Nsukka.

### Collection of *C. pentandra* germplasm and treatment application

Dried pods of Kapok were sourced from Unosi town in Ajaokuta Local Government Area of Kogi State in June, 2020. The pods were opened and the seeds extracted. The seeds were planted in nursery bags filled with cured sawdust. One month after seedling emergence, seventy-two uniformly sized seedlings were selected and transplanted to the field (see Fig. 2). The treatments were six rates of fertilizer application (Control (No fertilizer), 5 t ha<sup>-1</sup> of poultry manure + 200 kg ha<sup>-1</sup> of NPK, 10 t ha<sup>-1</sup> of poultry manure, 20 t ha<sup>-1</sup> of poultry manure, 450 kg ha<sup>-1</sup> of NPK, and 20 t ha<sup>-1</sup> of poultry manure + 100 kg ha<sup>-1</sup> of NPK). The field experiment was a randomized complete block design (RCBD) and replicated four times. The seedlings were transplanted at inter-row distance of 3 m and intra-row distance of 2 m on a single row plot of 3 plants. Planting holes (35 cm x 35 cm x 35 cm dimension) were dug in accordance to the plant spacing. An alleyway (3.0 m) separated two blocks. Fertilizers were applied to the seedlings at four weeks after transplanting. The fertilizer application was done in split doses, 40% and 60% of the required

quantity was applied in September, 2020 and November, 2020, respectively. The plants were watered heavily after the second application in order to allow plant roots to absorb the nutrients. Weeding was carried out at 4 weeks interval with the use of glyphosate.

### Collection of plant material

Succulent leaves (Fig.1) from the above experiment were collected and analyzed for minerals, vitamins and protein content. In this study, first to fourth leaf from the tip of the shoot were harvested and used for laboratory analyses. The experiment was arranged in a completely randomized design (CRD) with three replicates. The field experiment was set up having four replications while the laboratory experiment was replicated three times. Leaf samples were collected from replicate three and four, bulked together and used as replicate three for the nutritional qualities. The plant sample was authenticated by Mr Chijioko John Onyeukwu, Department of Plant Science and Biotechnology, Faculty of Biological Sciences, University of Nigeria, Nsukka.



Fig. 1: Succulent leaves of *C. pentandra*



Fig. 2: *Ceiba pentandra* plants

## Analysis of minerals

The official method of AOAC (2007) 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<sup>o</sup> 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).

Atomic absorption spectrometer (AA-7000) was used to determine calcium, magnesium, zinc and iron and absorbance read at wavelength of 422.7 nm, 285.2 nm, 213.9 nm and 248.3 nm, respectively.

## Vitamins determination

Vitamins were determined following the analytical procedure of AOAC (2007). In determining vitamin A, 2.0 g of sample was weighed into a set of conical flasks. The sample was saponified, extracted with 10 ml of xylene-kerosene mixture, shaken for 30 minutes and centrifuged for 25 minutes. The supernatant was run on the spectrometer at 328 nm and 460 nm respectively. Concentration of vitamin B<sub>12</sub> was determined using Spectrophotometer (Labomed Spectronic 21D) and the absorbance of samples was read at a wavelength of 510 nm. At a wavelength of 460 nm, absorbance, the standards and samples were read using fluorescent spectrometer to determine vitamin B<sub>2</sub>. Spectrophotometer (Spectronic 21D) at a wavelength of 15 seconds and 30 seconds was employed to determine vitamin C. At wavelength of 540 nm, vitamin B<sub>6</sub> was determined using Spectrophotometer (752P).

## Protein determination

Content of crude protein in the samples was determined by the routine micro Kjeldahl procedure/technique.

## Statistical analysis

Following the procedure for CRD, analysis of variance (ANOVA) was performed on triplicates data collected using GENSTAT (2013) statistical software. Comparison of treatment means was conducted using least significant difference (LSD) at 5% probability level.

## RESULTS

Soil properties of the experimental site prior to transplanting and the sample of poultry manure utilized in the experiment.

Properties of the soil from the study site prior to transplanting and the analysis of poultry manure used is shown in Table 1. The nitrogen content (0.098%) was very low and the available phosphorus (12.59 ppm) was also considered to be low. The potassium content, cation exchange capacity and base saturation were 0.10 mg/100g, 10.80% and 51.48%, respectively. The organic carbon (1.857%) and organic matter (3.201%) contents indicated that the soil was not fertile. The soil was characterized as sandy loam.

The poultry manure used had high organic matter, nitrogen, potassium and sodium contents with respective values of 85.12%, 1.315%, 0.18% and 0.0155%. The poultry manure also had high pH (8.5) in water which was strongly alkaline.

Table 2 presents the effect of fertilizer application rates on vitamin contents of *C. pentandra*. Fertilizer application rates had no significant ( $p > 0.05$ ) effect on vitamin contents of *C. pentandra*. However, application of poultry manure (PM) at 20 t ha<sup>-1</sup> which was supplemented with 100 kg ha<sup>-1</sup> NPK has the tendency to yield more vitamin A (0.110 mg/100g), B<sub>12</sub> (0.473 mg/100g) and B<sub>2</sub> (5.080 mg/100g) than others. Vitamin B<sub>6</sub> (6.030 mg/100g) was highly concentrated in leaves of *C. pentandra* grown with no fertilizer application, this will reduce cost of production. Application of 10 t ha<sup>-1</sup> of PM exhibited superiority in producing more vitamin C (4.790 mg/100g) than other treatment combinations.

**Table 1:** Soil properties of the experimental site prior to transplanting and the sample of poultry manure utilized in the experiment

<b>Mechanical properties</b>	<b>Soil Particle size (%) Poultry manure</b>	
Clay (%)	17	-
Silt (%)	9	-
Fine sand (%)	35	-
Coarse sand (%)	39	-
Textural class	Sandy loam	
<b>Chemical properties</b>		
pH in water	4.8	8.5
pH in KCl	3.8	8.1
Organic carbon (%)	1.857	58.905
Organic matter (%)	3.201	85.12
Total nitrogen (%)	0.098	1.315
Phosphorus (ppm)	12.59	0.52 (%)
<b>Exchangeable base</b>		
Sodium (Na <sup>+</sup> ) (mg/100g)	0.06	0.0155 (%)
Calcium (Ca <sup>2+</sup> ) (mg/100g)	4.20	6.8 (%)
Potassium (K <sup>+</sup> ) (mg/100g)	0.10	0.18 (%)
Magnesium (mg <sup>2+</sup> ) (mg/100g)	1.20	5.12 (%)
CEC (%)	10.80	-
Base saturation (%)	51.48	-
<b>Exchangeable acidity in me/100g soil</b>		
Aluminum (Al <sup>3+</sup> )	0.80	-
Hydrogen (H <sup>+</sup> )	2.40	-

Source: Soil Science Departmental Laboratory, University of Nigeria, Nsukka

- = not determined

Effect of fertilizer rates on mineral constituents (mg/100g) and protein content (%) of *C. pentandra* is shown in Table 3. Except for zinc and calcium contents, the rest of the mineral constituents and protein content were not significantly ( $p > 0.05$ ) influenced by fertilizer treatment. Sole application of 20 t ha<sup>-1</sup> of PM had the highest content of zinc (0.457mg/100g) which was not statistically different from the values (0.433 and 0.417 mg/100g) obtained in leaves of plants grown in plots without any soil amendment and 5 t ha<sup>-1</sup> of PM + 200 kg ha<sup>-1</sup> of NPK, respectively. The least value for zinc (0.370 mg/100g) was obtained when PM was applied at 10 t ha<sup>-1</sup>. Combined application of 5 t ha<sup>-1</sup> PM +

200 kg ha<sup>-1</sup> NPK had more concentration of iron (0.090mg/100g) than other treatments. Application of 5 t ha<sup>-1</sup> of PM combined with 200 kg ha<sup>-1</sup> NPK and 20 t ha<sup>-1</sup> PM + 100 kg ha<sup>-1</sup> NPK had the tendency to yield more magnesium (0.642 mg/100g) than others. More concentration of calcium (145.000 mg/100g) was recorded in the leaves of plants treated with PM at 5 t ha<sup>-1</sup> and supplemented with NPK at 200 kg ha<sup>-1</sup> while the least (119.200 mg/100g) was obtained in the control plot. Plants in the control plot had the highest protein content (19.860%) than other treatments, this imply that the production cost will drastically reduce.

**Table 2:** Effect of fertilizer rates on vitamin contents(mg/100g) of *C. pentandra*

Fertilizer rates	A	B <sub>12</sub>	B <sub>2</sub>	B <sub>6</sub>	C
0 t ha <sup>-1</sup>	0.098	0.373	4.370	6.030	1.440
5 t ha <sup>-1</sup> of PM + 200 kg ha <sup>-1</sup> of NPK	0.100	0.420	3.260	4.670	3.190
10 t ha <sup>-1</sup> of PM	0.097	0.383	3.360	5.660	4.790
20 t ha <sup>-1</sup> of PM	0.107	0.457	4.150	4.300	4.750
450 kg ha <sup>-1</sup> of NPK	0.110	0.463	4.340	5.750	3.790
20 t ha <sup>-1</sup> of PM + 100 kg ha <sup>-1</sup> of NPK	0.110	0.473	5.080	1.920	3.970
LSD (0.05)	Ns	Ns	Ns	Ns	Ns

Ns=non-significant

**Table 3:** Effect of fertilizer rates on mineral constituents (mg/100g) and protein content (%) of *C. pentandra*

Fertilizer rates	Zn	Fe	Mg	Ca	Protein
0 t ha <sup>-1</sup>	0.433	0.060	0.443	119.200	19.860
5 t ha <sup>-1</sup> of PM + 200 kg ha <sup>-1</sup> of NPK	0.417	0.090	0.642	145.000	16.940
10 t ha <sup>-1</sup> of PM	0.370	0.053	0.593	130.800	16.470
20 t ha <sup>-1</sup> of PM	0.457	0.050	0.337	129.200	17.820
450 kg ha <sup>-1</sup> of NPK	0.397	0.053	0.461	127.500	16.320
20 t ha <sup>-1</sup> of PM + 100 kg ha <sup>-1</sup> of NPK	0.378	0.053	0.642	127.500	18.380
LSD (0.05)	0.053	Ns	Ns	13.740	Ns

Zn-Zinc, Fe-Iron, Mg-Magnesium, Ca-Calcium. Ns=non-significant

## DISCUSSION

The result of this present work revealed that *C. pentandra* leaf contained vitamins. Fertilizer application rates did not have significant effect on vitamin contents of *C. pentandra*. The non-significant fertilizer difference obtained in vitamin contents indicated that vitamin constituents in the leaves were similar across the fertilizer treatments. The result is in agreement with the studies of Ndubuaku *et al.* (2015) who found non-significant effect of PM on vitamin contents of *Moringa oleifera* leaves in Nsukka. However, they reported lower values (0.58, 0.66 and 1.07 ppm) for vitamin A, B<sub>2</sub> and B<sub>6</sub>, respectively in leaves of poultry manure treated *Moringa oleifera* plants from Nsukka. The vitamin B<sub>12</sub> and B<sub>2</sub> found in the leaves of *C. pentandra* in this present study were higher compared to those obtained by Adepoju and Ugochukwu (2019) who reported vitamin B<sub>12</sub> and B<sub>2</sub> to be 0.24 and 0.19 mg/100g, respectively. Vitamin B<sub>2</sub> value recorded in this work was higher than (0.8 mg/100g) obtained by El Sohaimy *et al.* (2015) in *Moringa oleifera* leaves. The vitamin C

value recorded in this present study is comparable with 4.91 mg/100g reported by Friday *et al.* (2020) in Kapok leaves from Kogi State, Nigeria. Vitamins are considered necessary for cellular metabolism. Vitamin C protects against infection, hastens wound-healing, boosts the immune system and its antioxidant properties may lower the risk of developing cancer (Tsado, 2015). The variation in the contents of the nutrients reported by the various researchers could be linked to the differences in the environmental conditions (Ndubuaku *et al.*, 2015).

Fertilizer application rates positively influenced some of the mineral contents assessed. The quality of any farm produce is a function of the growing environment in which soil fertility management is a major determinant (Aba *et al.*, 2020). Higher accumulation of zinc in leaves harvested from plants grown with 20 t ha<sup>-1</sup> of PM might have resulted from availability of nutrients and general nutrition of *C. pentandra* plants by this rate. Aba *et al.* (2020) noted that organic foods generally possess a higher content of

mineral than those derived from conventional production system. Calcium content obtained in this study was more in leaves harvested from plants in plots that received PM at 5 t ha<sup>-1</sup> and augmented with NPK at 200 kg ha<sup>-1</sup>. This indicated that the complimentary use of PM and NPK fertilizer provided balanced nutrition for *C. pentandra* plants that resulted to higher concentration of calcium in the leaves. The values for iron obtained in this work were comparable to 62.20 ppm reported by Ndubuaku *et al.* (2015) in *Moringa oleifera* leaves grown with poultry manure in Nsukka, but values for zinc obtained in this study were higher than the 2.86 ppm found in their work. However, our value for magnesium was lower than the value (0.75%) they reported. Iron, zinc and calcium values recorded in this work were higher compared to 0.35, 0.04 and 7.66 mg/100 g reported by Friday *et al.* (2020) in fresh leave of *C. pentandra* from Kogi State. The values obtained for calcium in this work was higher compared to the report of Adepoju and Ugochukwu (2019) who obtained 119.38 mg/100g of calcium in *C. pentandra* leaves from Imo State. These minerals are required for normal functioning of the body. Calcium and phosphorus give bones their rigidity and are the major and essential component of bones and teeth in the human and animal body (Zhao *et al.*, 2019). Zinc is important for the maintenance of protein structure and nucleic acids (Soni *et al.*, 2017). Magnesium has extensive cellular effects as it supports normal functioning of ATP (adenosine triphosphate) and glucose metabolism (Enzonga *et al.*, 2019). Iron is important due to its role in metabolic processes including respiration and DNA synthesis (Okunlola *et al.*, 2019).

The protein content observed in this work (16.320 – 19.860%) is higher in comparison with 12.40% found by Ndubuaku *et al.* (2015) in *Moringa oleifera* leaves treated with different poultry manure rates in Nsukka. It is also higher than that of *C. pentandra* leaves from Anyigba (12.97%) as obtained by Friday *et al.* (2020). In contrast the crude protein value of 28.47% reported by Obi-Abang *et al.* (2019) in *C. pentandra* leaves is higher than the values obtained in this work. Proteins are essential in body building, boosts the immune system and aids cell division as well as growth (Osuntokun *et al.*, 2017). The variation observed in minerals and protein content may be due to genetic makeup and environmental differences. Olajide *et al.* (2020) reported

differences in proximate composition of 10 accessions of African walnut which suggested the probable roles of genetic diversity and variability in soils the accessions grew on.

## CONCLUSION

The study indicated that fertilizer treatment did not influence vitamin contents which imply that application of fertilizers produced similar effect on the vitamin contents irrespective of the rate. The study also established variation in some mineral contents of *C. pentandra* across the fertilizer rates. Zinc was more concentrated in the leaves of *C. pentandra* harvested in plots treated with poultry manure at 20 t ha<sup>-1</sup>. Generally, the iron values were found to be low in this study. Harvested leaves from plants in plots amended with poultry manure at 5 t ha<sup>-1</sup> and augmented with inorganic fertilizer at 200 kg ha<sup>-1</sup> had greater accumulation of calcium. Application of poultry manure at 20 t ha<sup>-1</sup> or poultry manure at 5 t ha<sup>-1</sup> supplemented with 200 kg ha<sup>-1</sup> NPK may be appropriate for growing *C. pentandra* since zinc and calcium were more concentrated in the leaves of plants treated with these rates. This information could guide the utility and domestication of *C. pentandra* for commercial cultivation. Sensitization campaign on the nutritional potential of this crop and further research on the effect of fertilizer application rates on nutritional qualities of *C. pentandra* is recommended.

## Conflict of interest

The authors have no conflict of interest to declare.

## Authors contribution

KO performed all the experiments while BKP and NUM supervised the study.

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