

Improving Vegetable Diversity and Micronutrient Intake of Nigerians Through Consumption of Lesser Known Silk Cotton (*Ceiba pentandra*) Leaf

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Abstract

The potential of Nigerian indigenous tree leaves as vegetable source, pharmaceuticals and other therapeutic materials have been reported. However, Silk cotton (*Ceiba pentandra*) leaf is still underutilised as vegetable in parts of Nigeria where it exists despite its potential great health benefits. The aim of the study was to assess the micronutrient and phytochemical potential contribution to nutrient intake of its consumers, and acceptability of its cooked soup and sauce 'as consumed'.

Fresh young shoots and leaves of *Ceiba pentandra* were harvested from Ihitte/Uboma in Imo State, Nigeria. Composite sample of the leaf was prepared and divided into four portions. One portion was labelled as raw sample, and others blanched, cooked to soup and sauce. The four samples were analysed for proximate, minerals, vitamins and phytochemical composition using standard methods of AOAC. Sensory evaluation of soup and sauce was carried out using 9-point hedonic scale with 30 untrained panelists. Data were analysed using ANOVA at $p < 0.05$

Raw *Ceiba pentandra* leaf contained 80.9g moisture, 3.9g protein, 0.8g fat, 15.3g carbohydrate, 68.40 kcal gross energy, 183.40mg potassium, 119.38mg calcium, 112.99mg phosphorus, and 3.46mg iron/100g sample. The leaf was rich in phytochemicals such as saponins, flavonoid and alkaloids. Raw sample was highest in water-soluble vitamins while the sauce was highest in β -carotene (339.72 μ g/100g). Cooking the leaf to soup and sauce significantly increased the mineral content of the products ($P < 0.05$) with reduction in water-soluble vitamins and phytochemicals ($P < 0.05$). The sensory attributes of the soup and sauce were generally acceptable to the panelists, with the sauce being more acceptable.

The leaf and its products were rich in essential minerals, vitamins and phytochemicals. The sauce retained more nutrients compared to other samples. Inclusion of this underutilised vegetable in diets will reduce micronutrient malnutrition, promote dietary diversity, good health and wellness.

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Keywords: *Ceiba pentandra* leaf, dietary diversity, vegetable soup, sauce, micronutrients.

Received: Feb 08, 2019

Accepted: Apr 04, 2019

Published: Apr 10, 2019

Editor: Mark L. Heiman, MicroBiome Therapeutics LLC, 1316 Jefferson Ave., New Orleans, United Kingdom.

Introduction

Leafy vegetables are grown mainly in the gardens and consumed as side dish or soup with starchy staples among many Nigerians. They are of special nutritional importance being good sources of fat and water-soluble vitamins¹. They are highly beneficial for maintaining health and preventing diseases. Dark green leafy vegetables provide high amounts of micro-minerals which play vital roles in nutrient metabolism and retard degenerative diseases². Gropper et al.³ suggested the need to consume high vegetable meals to prevent colon and stomach cancers. Ball⁴ reported a high vitamin, dietary fibre and mineral content in vegetables and the role they play in maintaining alkalinity in the body. The high dietary fibres in green leafy vegetables help in regulating the digestive system, aiding bowel health and weight management^{5,6}.

Several studies have shown that high dietary fibre intake may lower the risk of colon cancer^{5,6,7}. Green leafy vegetables are generally low in calorie and contain low carbohydrate content but high in fibre. These make them important in promoting and maintaining healthy body weight and ideal for reducing the risk of developing type II diabetes. Quite a large number of African indigenous leafy vegetables have long been known and reported to have health promoting properties and uses⁸. Several of these indigenous leafy vegetables continue to be used for prophylactic and therapeutic purposes in rural communities.

Silk cotton (*Ceiba pentandra*) is a tropical tree of the order *Malvales* and the family *Malvaceae*. It is the largest African forest tree and severally known among some Nigerian ethnic groups as *Rimi* (Hausa), *Bamtami* (Fulani), *Araba ogungun* (Yoruba) and *Apu* (Igbo)⁹. Kapok is the most commonly used name for the tree. The tree is also known as the Java cotton, Hara kapok, Silk cotton or Ceiba¹⁰. The leaves of *Ceiba pentandra* have been reported to have both nutritional and medicinal properties. In Nigeria, especially in some part of South-west and South-east geo-political zones, the leaves are cooked in form of slurry sauce comparable to Okra. The young leaves or the shoots are normally used for soup, and a powder prepared from its dried leaves is used to prepare sauce during the dry season¹¹.

African leafy vegetables have long been reported and continue to significantly contribute to dietary vitamin and mineral intakes of local populations¹². Copious consumption of vegetables treats hemorrhoids, gallstones, obesity and constipation; the antioxidants in vegetables decrease the risk of heart disease and vitamin K contents of dark green leafy vegetables provide a number of health benefits including bone protection from osteoporosis and protection against inflammatory diseases¹³. In Nigeria, insufficient efforts have been made in assessing the nutritional value of less utilized indigenous green leafy vegetables, and knowledge about their consumption is low, leading to many of them going into extinction unnoticed. Nutrient analysis of indigenous vegetables can lead to better understanding of their nutritional importance¹⁴ and improve biodiversity as well as dietary diversity. This study was therefore undertaken to evaluate the nutrient composition and micronutrient potential of raw and cooked *Ceiba pentandra* leaf as a means of promoting vegetable dietary diversity in Nigeria.

Materials and Methods

Sample Collection and Preparation

Young shoots and fresh leaves of *Ceiba pentandra* were harvested from Ihitte/Uboma Local Government Area (LGA) of Imo State, Southeast Nigeria. The sample preparation was carried out at the Department of Human Nutrition, University of Ibadan, Ibadan, Oyo State, Nigeria. The leaves were cleaned by removing any extraneous materials and thoroughly mixed together to obtain composite sample, after which it was divided into four portions. One portion was treated as raw (Sample 1), another portion was blanched (Sample 2). The third portion was prepared into local Soup (Sample 3), while the fourth portion was prepared into sauce (Sample 4).

Soup and Sauce Preparation

For the soup, the vegetable was washed and sliced with kitchen knife. Palm oil was heated in a pot for 1 minute; chopped onions, grinded pepper, salt, bouillon cubes, Crayfish and water were added and allowed to steam for ten minutes. The sliced vegetable was finally added and allowed to cook for about 5 minutes. For the sauce, the washed vegetable was blanched in hot water for about 2 minutes and drained. The blanched

vegetable was then mashed. Palm oil was heated in the pot and diced onions was added and allowed to steam for 1 minute. Pepper, salt, bouillon cubes and water were added and allowed to boil. The mashed vegetable was added, stirred and allowed to cook for about 2 minutes. (Figure 1 to 4), (Table 1).

Chemical Analysis

Proximate Composition

The method of Association of Official Analytical Chemists (AOAC)¹⁵ was used to determine the moisture, protein, ash, fat and crude fibre content, while carbohydrate was obtained by difference and Gross energy of the samples determined by ballistic bomb calorimetric method¹⁵. All determinations were carried out in triplicate.

Mineral Content

Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, with the readings taken on Jenway digital flame photometer/spectronic20¹⁵. Phosphorus was determined by Vanado-molybdate colorimetric method¹⁵. Calcium,

magnesium, zinc, manganese, copper and selenium were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer and compared with absorption of standards for these minerals¹⁵.

Vitamin Content

Beta-carotene, B-vitamins, and ascorbic acid were determined using the standard methods of vitamins assay reported by AOAC¹⁵.

Phytochemical Analysis

Phytate was determined by titration with standard iron (III) chloride solution. The tannin content was determined by extracting the samples with a mixture of acetone and acetic acid for five hours, measuring their absorbance and comparing the absorbance of the sample extracts with the absorbance of standard solutions of tannic acid at 500 nm on spectronic20. Saponin was also determined by comparing the absorbance of the sample extracts with that of the standard at 380 nm, flavonoids by aluminum chloride colorimetric method described by Chang et al.¹⁶, alkaloids by gravimetric method of Harbone as



Figure 1. Silk Cotton tree

Source: Plant Resources of Tropical Africa/Resources Wageningen, Netherland (Duvail, 2009).



Figure 2. Silk Cotton (*Ceiba pentandra*) leaves (Forest and Kim Starr, 2014).

Source: Plant Resources of Tropical Africa/Resources Wageningen, Netherland (Duvail, 2009).



Figure 3. Young leaves of *Ceiba pentandra*



Figure 4. Sauce prepared with *Ceiba pentandra* leaves

Table 1. Recipes for Soup and Sauce prepared with *Ceiba pentandra* leaves

Ingredients	Soup	Sauce
Onions	30g	40g
Pepper	15g	15g
Crayfish	40g	-
Salt	15g	10g
Bouillon cubes	4g	4g
Palm oil	35g	40g
<i>Ceiba pentandra</i> leaves	250g	250g
Water	1000ml	300ml

described by Onwuka¹⁷ and glycosides by the methods described by Harborne¹⁸.

Sensory Evaluation

The sensory evaluation of the cooked soup and sauce samples was carried out for consumer acceptance and preference using 30 untrained panelists recruited among staff and students of the University of Ibadan. Informed consent of the students was sought through the signing of statement provided to the students. A structured questionnaire consisting of close ended questions arranged in a tabular form was designed and presented to the panels. A nine (9) point Hedonic scale (with 1 and 9 representing "extremely dislike" and "extremely like" respectively) was used to score the samples for colour, taste, aroma, texture, and general acceptability.

Statistical Analysis

The data obtained was analysed statistically using Statistical Package for Social Sciences (SPSS) version 20. One-way ANOVA was used to determine the difference between groups. All data was expressed as Mean \pm Standard deviation of triplicate determination, the difference between groups considered significant at $P < 0.5$

Results

Table 2 shows the result of proximate composition of the four samples. The raw sample (sample 1) was very high in moisture content, low in crude protein, ash and carbohydrate, and very low in fat and gross energy. Steaming resulted in increase in the moisture content of the blanched sample (sample 2) with attendant reduction in other nutrients. However, preparing the vegetable into soup (sample 3) and sauce (sample 4) led to significant reduction in moisture and fibre content with significant increase in other nutrients ($p < 0.05$), especially protein, fat and gross energy content of the products compared to the raw and blanched samples.

In Table 3, the raw sample contained substantial amount of potassium, calcium, magnesium, phosphorus and iron. There was a significant reduction in most of the macro-minerals in the blanched sample (sample 2) compared with the raw sample ($p < 0.05$). Processing the leaf to soup and sauce led to significant increase

($p < 0.05$) in all the minerals studied compared with both raw and blanched samples, no significant difference ($p > 0.05$) in the manganese and selenium contents of the raw and processed samples was observed. The raw sample was rich in β -Carotene, vitamins B₁, B₃, B₆ and ascorbic acid. Blanching and cooking into soup and sauce resulted in significant reduction in values of the water-soluble vitamins ($p < 0.05$). However, there was no significant difference in the β -Carotene values for samples 1 and 4 (Table 4).

The raw leaf contains appreciable amounts of phytochemicals, especially phytates, saponins, glycosides and alkaloids (Table 5). Significant reduction ($p < 0.05$) was found in all the phytochemical components in the processed samples. The cooked sauce had the highest level of reduction of phytochemicals followed by cooked soup ($p < 0.05$). Both the soup and sauce were scored well by the sensory Assessors (Table 6). The soup (sample 3) was rated better in texture, while the sauce (sample 4) was rated higher in colour, odour, taste ($p < 0.05$) and general acceptability ($p > 0.05$).

Discussion

The value obtained for the moisture content of raw *Ceiba pentandra* leaves (sample 1) was in line with the report of Enechi *et al.*¹⁰. High moisture content in vegetables is characteristic of the degree of its freshness, perishability and susceptibility to microbial attack. Generally, the processed samples (Samples 2, 3 and 4) were high in moisture content. The increase in moisture content of blanched sample above the fresh one could be due to water absorption by the fibres and other natural chemical component of the vegetables. The lower moisture content for the soup and sauce compared with the raw sample was believed to be due to the added ingredients.

The value for crude protein content of fresh *Ceiba pentandra* leaf was within the range of protein content of green leafy vegetables reported by Ball²⁰, but lower than the value reported by Anosike *et al.*²¹. The crude protein decreased with blanching, and this agrees with what was reported by Komolafe and Obayanju²². The reduction in crude protein content of the blanched sample is believed to be due to leaching of soluble protein into the water. Preparing the vegetable to either

Table 2. Proximate Composition of raw and processed *Ceiba pentandra* leaf (g/100g fresh matter/as consumed) *

Parameter / Sample	1	2	3	4
Moisture	80.9 ± 0.31 ^a	88.0±0.63 ^b	66.9 ± 0.23 ^c	67.2 ± 0.03 ^c
Crude Protein	3.9± 0.01 ^a	3.4±0.05 ^b	6.0 ± 0.06 ^c	5.9 ± 0.09 ^c
Crude Fat	0.8 ± 0.01 ^a	0.6 ± 0.02 ^b	10.6 ± 0.02 ^c	10.9 ± 0.02 ^d
Crude Fibre	3.3± 0.01 ^a	1.4 ± 0.01 ^b	1.2 ± 0.01 ^c	1.4 ± 0.02 ^b
Ash	0.6± 0.01 ^a	0.5 ± 0.01 ^b	1.4 ± 0.02 ^c	1.8 ± 0.02 ^d
Carbohydrates	10.5 ± 0.31 ^a	5.4 ± 0.70 ^b	13.9± 0.23 ^c	12.8 ± 0.08 ^d
G. Energy (kcal/)	78.40±0.09 ^a	46.54±0.15 ^b	180.43±0.23 ^c	177.49±0.13 ^d

*Values are means and standard deviations of triplicate determinations

Values with same superscript on the same row are not significantly different (p> 0.05)

Sample 1= Raw silk cotton leaf; Sample 2 = Blanched silk cotton leaf; Sample 3 = Soup prepared with silk cotton leaf; Sample 4 = Sauce prepared with silk cotton leaf; G. Energy = Gross Energy

Table 3. Mineral composition of *Ceiba pentandra* leaf (mg/100g fresh weight/as consumed)*

Parameters / Sample	1	2	3	4
Sodium	68.93±0.42 ^a	47.08±0.07 ^b	170.04±2.23 ^c	196.92±2.13 ^d
Potassium	183.40±0.74 ^a	161.78±1.75 ^b	372.58±1.34 ^c	404.03±2.67 ^d
Calcium	119.38±1.04 ^a	118.39±1.41 ^b	238.82±2.23 ^c	275.00±2.64 ^d
Magnesium	102.48±0.81 ^a	86.21±1.40 ^b	200.64±2.67 ^c	232.76±2.67 ^d
Phosphorus	112.99±0.59 ^a	102.46±1.40 ^b	220.89±1.69 ^c	255.77±2.13 ^d
Iron	3.63±0.74 ^a	2.72±1.75 ^b	9.21±2.67 ^c	10.41±3.20 ^d
Copper	0.49±0.01 ^a	0.40±0.01 ^b	0.78±0.02 ^c	0.87±0.02 ^d
Zinc	1.30±0.01 ^a	0.61±0.03 ^b	1.76±0.01 ^c	1.96±0.01 ^d
Manganese	0.61±0.01 ^a	0.60±0.01 ^a	0.68±0.01 ^a	0.73±0.03 ^a
Selenium (µg/)	0.01±0.00 ^a	0.01±0.01 ^a	0.01±0.00 ^a	0.01±0.00 ^a

Values with same superscript on the same row are not significantly different (p> 0.05)

*Values are means and the standard deviations of triplicate determinations.

Table 4. Vitamin content of *Ceiba pentandra* leaf (mg/100g fresh weight/as consumed)*

Parameter / Sample	1	2	3	4
β-Carotene (µg/)	330.70±0.17 ^a	297.13±0.29 ^b	312.96±0.58 ^c	339.72±0.35 ^d
Vitamin B ₁	3.49±0.02 ^a	1.67±0.02 ^b	0.18±0.03 ^c	0.15±0.02 ^c
Vitamin B ₂	0.19±0.03 ^a	0.14±0.02 ^a	0.08±0.01 ^a	0.06±0.01 ^a
Vitamin B ₃	5.76±0.02 ^a	1.90±0.02 ^b	1.08±0.02 ^b	1.04±0.02 ^b
Vitamin B ₆	2.27±0.03 ^a	0.87±0.02 ^b	0.50±0.02 ^b	0.45±0.02 ^b
Vitamin B ₁₂	0.24±0.03 ^a	0.15±0.01 ^a	0.93±0.02 ^a	0.06±0.01 ^b
Ascorbic acid	36.41±0.03 ^a	32.51±0.02 ^b	21.76±0.02 ^c	18.95±0.03 ^d

Values with the same superscript on the same row are not significantly different (p> 0.05)

*Values are means and standard deviations of triplicate determinations

Table 5. Phytochemical component of *Ceiba pentandra* leaf (mg/100g fresh weight basis/as consumed)*

Parameter / Sample	1	2	3	4
Phytate	2.71±0.54 ^a	1.37±0.00 ^b	0.82±0.02 ^c	0.78±0.02 ^c
Tannin	0.06±0.25 ^a	0.03±0.48 ^a	0.02±0.00 ^b	0.01±0.00 ^b
Saponin	3.97±0.08 ^a	2.28±0.34 ^b	1.71±0.03 ^c	1.66±0.02 ^d
Glycoside	2.69±0.39 ^a	1.18±0.03 ^b	0.32±0.34 ^c	0.29±0.34 ^c
Flavonoid	0.08±0.00 ^a	0.04±0.18 ^b	0.02±0.00 ^c	0.01±0.00 ^d
Alkaloid	3.19±0.60 ^a	1.27±0.01 ^b	1.01±0.03 ^b	0.90±0.02 ^b

Values with the same superscript on the same row are not significantly different (p> 0.05)

*Values are means and the standard deviations of triplicate determinations

Table 6. Sensory Evaluation of Soup and Sauce prepared with *Ceiba Pentandra* leaf

Parameters	3	4
Colour	6.63±1.47 ^a	7.30±1.47 ^b
Aroma	7.73±0.94 ^a	7.77±1.10 ^b
Taste	7.27±1.57 ^a	7.77±1.19 ^b
Texture	7.23±1.32 ^a	7.17±1.31 ^b
General acceptability	7.33±1.32 ^a	7.63±1.45 ^a

Values with same superscript on the same row are not significantly different ($p > 0.05$).

*Values are means and standard deviation of thirty sensory panelists' score (n = 30)

Sample 3 = Soup prepared with silk cotton leaf; Sample 4 = Sauce prepared with silk cotton leaf

soup or sauce however increased the protein content of the products, which might have resulted from the contribution of the added ingredients. The raw leaf was very low in fat content which is characteristic of most leafy vegetables. The fat value is comparable to the values reported in the literature for *Solanecio bialfrae* and *Solanum nigrum* with values of 0.92% and 0.96% respectively²³. However, an increase was observed in the fat content of samples 3 and 4 due to addition of palm oil during cooking. Dietary fats function in increasing the palatability of food by absorbing and retaining flavours²⁴.

The raw and processed samples' crude fibre values are within the values reported for some commonly consumed vegetables such as *Celosia argentea* (1.8%)¹⁹, *Ocimum gratissimum* (3.89%), *T. triangulaire* (2.57%) and *Telfaria occidentalis* (4.22%)¹. The dietary fibre in green leafy vegetables helps to regulate the digestive system, aid bowel health and weight management⁶. The significant reduction in crude fibre content of the processed samples (samples 2, 3, 4) compared with the raw sample is suggestive of presence of soluble fibre content in the leaf.

The carbohydrate content of the studied leaf is lower than what was reported by Enechi *et al.*¹⁰ and Friday *et al.*¹¹. The carbohydrate content of the leaf was significantly reduced ($p < 0.05$) with blanching, and increased in samples 3 and 4 due to the added ingredients used in the cooking. The low carbohydrate

content of the leaves could be of importance in the treatment of diabetes and its associated complications such as coronary artery disease²⁵ as well as weight reduction. The gross energy content of the raw sample was observed to be slightly lower than what was reported by Raimi *et al.*²⁶. The gross energy significantly increased in samples 3 and 4, which was believed to be a direct result of added ingredients which resulted in significant increase in their protein, fat and carbohydrate content.

The raw sample contained appreciable amount of essential minerals such as potassium, calcium, magnesium, iron, and moderate amount of sodium, and hence, can serve as good source of these minerals. However, blanching resulted in slight reduction in value of the minerals in sample 2, and this is similar to the findings of Shahnaz *et al.*²⁷ and Oboh²⁸, who observed that conventional food processing techniques such as blanching and cooking caused significant decrease in mineral content of vegetables. There was an increase in the mineral content of samples 3 and 4, with sample 4 having the highest values for all the minerals. Increase in the mineral content of samples 3 and 4 could have resulted from the ingredients added.

The raw *C. pentandra* leaf was rich in beta carotene, vitamins B₁, B₃, B₆ and ascorbic acid which were significantly reduced by processing. However, there was slight increase in the beta carotene content of the sauce. This observation is in line with the report of

USDA²⁹ that moderate cooking increases the availability of β -carotene in the vegetables as a result of breakdown of plant cell walls of the vegetables. Rickman *et al.*³⁰ also stated that loss of soluble solids and release of protein-bound β -carotenes that occur during boiling may contribute to the observed increase in the pro-vitamin content. The significant reduction in B-vitamins and ascorbic acid content of samples 3 and 4 was believed to be due either to their destruction by heat or their leaching to washing water and blanching process before cooking.

The raw vegetable leaf contains substantial amounts of phytochemicals with health promoting benefits. The flavonoid in the fresh sample is much lower compared to the value reported by Friday *et al.*¹¹. Phytochemicals such as beta carotene, ascorbic acid, flavonoids, alkaloids, tannins and saponins have antioxidant activity which protect body cells against oxidative damage, thereby reducing the risk of developing certain types of cancer. Phytochemicals also interfere with the replication of DNA cells, prevent the multiplication of cancer cells and play a role in prevention of some hormone-dependent cancers such as breast and prostate cancer³¹. A significant reduction was observed in the phytochemical content of processed samples, especially in soup and sauce. This finding is in support of the findings of Aganga and Tshwenyane³² and Ogbadoyi *et al.*³³ who reported that boiling of vegetables in water ruptures the cell walls which can subsequently cause the leaching of the cell contents including the phytochemicals and toxic substances.

The Panelists rated both the soup and sauce highly in all the parameters tested. However, the vegetable sauce was rated higher for its colour, taste, aroma and general acceptability. This may be because the sauce contained more onions and palm oil, and was fried for a longer time than the soup.

Conclusion

The leaf of *Ceiba pentandra* contains significant quantities of essential micronutrients such as potassium, calcium, magnesium, phosphorus, iron, β -carotene, ascorbic acid, and the B-vitamins, and its nutrient content compares favourably well with that of commonly consumed vegetables. The presence of phytochemicals in the vegetable confers promotion of health and

medicinal values on it. Its fibre content also qualifies it as a good and desirable vegetable for dietary diversity. Blanching the vegetable led to loss of more nutrients compared to the soup and sauce. Addition of some ingredients during processing significantly improved the nutrient content of the cooked samples; therefore, there is the need to popularise the consumption of this vegetable in the areas where it is available as a means of improving dietary diversity, health and nutritional status of people.

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