Early Growth Performance of Seedlings and Nutritional Composition of *Plukenetia conophora* Mull. Arg. Nuts: A Threatened Forest Food Species

Akachuku, C. O.
Department of Forestry and Environmental Management, College of Natural Resources and Environmental Management, Michael Okpara University of Agriculture, Umudike
Correspondance E-mail: doctocaroaka@yahoo.com

Abstract

Early growth performance and nutritional composition of Plukenetia conophora were studied. The objectives of this study were to determine the (i) effect of pod size on early growth performance of the seedlings; and (ii) the nutritional composition of its nuts. Pods with different number of seeds ranging from 1 to 4 seeds per pod were selected for the study and were classified into four size classes based on the number of seeds per pod. Twenty pods were selected from each of the classes. Seeds from different classes were raised in 30 polythene pots per class in the nursery. The following growth parameters were measured every fortnight for a period of twelve weeks: stem height (cm), stem girth (cm), total number of leaf per plant and total leaf area per plant (cm^2). Size class 4 (4-seeded pods) on the average had the highest total stem height of 125.71 cm, total stem girth of 10.84 cm, total leaf number of 12 and total leaf area of 145.71 cm^2. Significant relationship (r^2=0.93) occurred between pod width (cm) and pod weight (g), the smallest size class (1-seeded pod) had the least growth values. The results of the proximate analysis showed that protein content of the raw and boiled seeds were 27.2% and 26.5%, respectively. Boiling also reduced vitamin C concenration from 62.44mg/100g to 35.7mg/100g.

Keywords: Growth performance, nutritional composition, Plukenetia conophora, size classes.

Introduction

Nigeria is blessed with several forest food species usually referred to as Edible-Non-Timber-Forest Products (E-NTFPs). Although most of these species can be propagated, a large proportion is being collected from the wild. The incessant demands for food, wood and other raw materials have led to increase in deforestation and subsequently reduction in species, varieties within species and in some cases extinction of some species.

Lack of adequate information on the efficient cultivation techniques and utilization potentials of most of these E-NTFPs and non-consistent research efforts on them hamper their propagation, consumption level and industrial utilization. According to Ayua and Ajai (1997), humanity in its restless pursuit of economic growth is changing the face of the earth. Already, a large number of species have become locally extinct, while a few others are globally extinct. Information on the growth performance of NTFPs is very scanty. According to Anegbeh and Ladipo (1994), growth characteristics of E-NTFPs are highly needed by farmers for efficient production and management in home gardens and cultivated fields as well

as their conservation in the wild. Most of the forest food species are harvested from the wild without their corresponding domestication (Akachuku, 2005). Forest resources are being lost to major land uses such as agriculture, commercial logging, livestock grazing, construction and mining. At the same time, population growth and migration are placing increasing stress on the remaining natural resources. Deforestation does not only affect the productive potential of plants but also results in species extinction and habitat loss (Lusigi, 1991). Agenda 21 which is the action programme adopted at the 1992 UN Conference on Environmental and Development (UNCED), discusses the predicament of low-income people and their relationship to forest environments. It also involves combating poverty and protecting forests. Agenda 21 also emphasises the need for environmental monitoring and helping forest resources users gain access to information needed for effective resources management.

In South-eastern Nigeria, species such as *P. conophora* (conophora nut), *Irvingia gabonensis* (African Mango), *Treculia africana* (African breadfruit), *Dennettia tripetala* (pepper fruit) are already classified as threatened species because of over-population resulting in habitat destruction as a result of increasing demands for infrastructural development (Akachuku, 1996). Many researchers have carried out studies on a few forest food plant species (Okigbo, 1977; Okafor, 1981; Denton and Ojeifo, 1993; Gbile, 1993; Akachuku, 1996). Awodoyin *et al*. (2000) studied the biology, germination and prospects for the domestication of *P. conophora* obtaining an average percent germination of 72.32% after seed treatment. However, the seeds were not collected according to pod-size classes to determine the effect of pod-size on germination percentage. Also, Ogunsua and Adebona (1983) determined the chemical composition of conophora nut but not the phytochemical composition of the raw and cooked nut. There is therefore the need for further studies on this threatened forest food resource to enhance its propagation and utilization potential.

Forest food species do not serve only as sources of food and food supplements but also serve as industrial raw materials as a result of their phytochemical contents. This study examined (i) early growth performance of the seedlings, (ii) relationships among the growth parameters and, (iii) the nutritional composition of raw and boiled nuts.

Materials and Methods

Study Area

The study was carried out in Abia State, South-eastern Nigeria. The area lies between latitude 5^0 28′54.4′′N, longitude 7^0 32′45.5′′E and altitude 122m above sea. The climate of the study area is characterized by heavy rainfall ranging from 1911.4 to 2055.5 mm per annum with bimodal peaks in July and September and a short dry period usually occurring in August (NRCRI, 2005). The climate is typically tropical with markedly two (wet and dry) seasons. The relative humidity is very high during the wet season ranging from 73 to 77.8% (NRCRI, 2005). Solar energy is most intense and the maximum temperature ranges from 31.9^0C to 32.05^0C, while the minimum temperature ranges from 22.4^0C to 22.5^0C (NRCRI, 2004, 2005). The soil is largely sandy

loamy and the vegetation is that of lowland rainforest

Field study

A field survey was carried out in Ikwuano Local Government Area [latitude 5^0 28'54.4"N, longitude 7^0 32'45.5"E] to identify the mother plants of *P. conophora*. Thirty mother plants were randomly selected from 90 identified mother plants. . A total of 300 fruits of *P. conophora* that had fallen under the mother plants were hand-picked. The pods were grouped into size classes, based on the number of seeds per pod; one-seeded pods as size class I; two-seeded as size class II; three-seeded as size class III and four-seeded as size class IV. The need to classify the pod based on size is because each plant can produce pods of different sizes.

A total of 20 fruits were randomly selected from each size class and the following measurements were taken: fruit weight (g), fruit length (cm), and total seed number per fruit, total seed weight (g), individual seed weight (g), and fruit bark weight (g). Seeds from different size classes were planted in sandy loamy soil contained in polythene pot (nursery grade bags). Ten polypots were used to raise seeds from each class. The pots were arranged in a completely randomized design (CRD) and replicated three times (30 polypots per size class) giving a total of 120 polypots containing seeds of the four different size classes.

Measurements of the growth parameters commenced three weeks after seedling emergence because of the delicate nature of the seedlings. The growth parameters were then measured every fortnight for three months. The growth parameters measured were: stem height (cm), stem girth (cm), total number of leaves per plant and total leaf area per plant (cm^2). Stem height was measured using thread and ruler, while stem girth was measured at 5 cm above soil level using a vernier calliper. Total number of leaves per plant were counted and recorded, while total leaf area per plant was measured using a non-destructive graph method. This method involves tracing a leaf in each size class on a graph sheet to determine the leaf area and then multiplying each area by the total number of leaves in its size class. The total leaf area per plant was then calculated by adding the leaf areas of all size classes.

Determination of the Proximate Composition

The raw and boiled nuts of *P. conophora* were analysed for nutrient composition. Moisture content was measured using the dry oven method according to AOAC (2005). Ash content was determined using furnace incineration gravimetric method (James, 1995). Five grams of the processed sample was measured into a previously weighed porcelain crucible. The sample was burnt to ashes in a muffle furnace at 550^0C and weighed after cooling. The weight of the ash was then calculated as a percentage as follows:

$$\textbf{Ash (\%)} = \frac{\mathbf{W_2 + W_1}}{Weight\ of\ sample} \times \frac{\mathbf{100}}{\mathbf{1}}$$

Where: W_1 = Weight (g) of empty crucible
W_2 = Weight of crucible + Ash

Fat content by semi-continuous solvent extraction gravimetric method as described by Minn and Boff (2003) using

soxhlet apparatus while Crude fibre was measured by Weende gravimetric method as described by Pearson (1976) and James (1995). Crude protein was by Kjeldahl method in which total nitrogen (N_2) was calculated and multiplied by a factor of 6.25 to obtain the protein content (Pearson, 1976; James, 1995; Ochang, 2005).

Determination of mineral and vitamin content

The dry extraction method described by James (1995) was used. The extract obtained by this process was used to determine the mineral composition of the raw, boiled seeds and fruit-bark of *P. conophora*. Calcium and Magnesium contents of the sample were determined by the varsonate EDTA complex iometric titremetric method (Pearson, 1976; James, 1995). Phosphorus was determined by Vanado-molybdate (Yellow) colorimetric method (James, 1995). Potassium and sodium were determined by flame photometry (James, 1995). Vitamins A, C and E content were determined using the method of the Association of Vitamin Chemists (AVC) described by Pearson (1976). The statistical method of analysis used include ANOVA, regression analysis and Least Significant Difference (LSD) at $p<0.05$.

Results

Morphological characteristics of *Plukenetia conophora* pods and their inter-relationships

The results showed that weight, length and width of pod increased with increasing number of seeds per pod. Significant differences occurred among the different pod-size classes in all the morphological characteristics, with the exception of pod length, where there was no significant difference. The pod weight and pod length increased significantly with increasing number of seeds per pod from one-seeded to four-seeded pods (Table 1). Similarly, pod width for the different size classes increased with increase in number of seeds per pod, however pod width for the three-seeded and four-seeded pods were similar. Seed weight was nor significantly different between one-seeded and two-seeded pods, but their weight was significantly lower than in four-seed pods. The weight of the pod bark was significantly higher for three-seeded and four-seeded pods compared to one- or two-seeded pods.

The inter-relationship among the morphological characteristics of the different size classes of *P. conophora* pods are shown on Table 2. Variations occurred among the morphological characteristics within and among the different size-classes. Very highly significant relationship occurred between pod width and pod weight in pod size-class one, bark weight and pod weight in size-class two and, total seed weight and pod weight in size-class four. In size-class three, a highly significant relationship occurred between bark weight and pod weight.

Table 1: Morphological characteristics of *Plukenetia conophora* pods of different sizes

Pod-Size Class	Pod Weight(g)	Pod length(cm)	Pod Width (cm)	Total Seed Weight (g)	Pod-bark Weight (g)
One-seeded	59.24	13.99	17.12	10.05	50.19
Two-seeded	90.18	14.88	21.82	19.35	69.37
Three-seeded	149.70	17.39	24.39	30.79	118.89
Four-seeded	175.99	18.29	24.24	46.29	123.69
LSD (0.05)	16.17	0.07	1.68	12.98	12.98

LSD = least significant different at $p< 0.05$.

Table 2: Inter-relationships among the morphological characteristics of the different pod sizes of *Plukenetia conophora*

Parameters	**Pod length (cm)**	**Pod width (cm)**	**Bark weight (g)**	**Total seed weight (g)**
One-seeded pods				
Pod weight	0.410*	0.870***	0.610**	0.019^{NS}
Pod length		0.076^{NS}	0.006^{NS}	0.417*
Pod width			0.600**	0.018^{NS}
Bark weight				0.021^{NS}
Two-seeded pods				
Pod weight (g)	0.610**	0.470*	0.880***	0.013^{NS}
Pod length (cm)		0.194^{NS}	0.510*	0.165^{NS}
Pod width (cm)			0.564**	0.001^{NS}
Bark weight (g)				0.001^{NS}
Three-seeded pods				
Pod weight (g)	0.078^{NS}	0.032^{NS}	0.650**	0.366^{NS}
Pod length (cm)		0.528*	0.030^{NS}	0.450*
Pod width (cm)			0.007^{NS}	0.163^{NS}
Bark weight (g)				0.207^{NS}
Four-seeded pods				
Pod weight (g)	0.660**	0.338^{NS}	0.500*	0.770***
Pod length (cm)		0.505**	0.510**	0.670**
Pod width (cm)			0.309^{NS}	0.419*
Bark weight (g)				0.530**

Level of significance: NS – Not significant

* Significant at 5% probability level (significant)

** Significant at 1% probability level (highly significant)

*** Significant at 0.1% probability level (very highly significant)

The regression analysis (r^2) obtained showed that pod width (cm) can be predicted from pod weight (g) in one seeded pods of *P. conophora*, $r^2 = 0.87$ (Table 3).The results also showed that bark weight (g) can be predicted from pod weight (g) in two-seeded pod, $r^2 = 0.88$, while total seed weight can also be predicted from pod weight (g) to some extent in four-seeded pod, $r^2 = 0.77$ (Table 3).

Table 3: Predictive equations of the significant relationships among the morphological characteristics of various pod-size classes of *Plukenetia conophora*

Inter-relationships	Pod-size class	Predictive equation
Pod weight (g) and pod width (cm)	One-seeded	$y = 6.494 + 0.177x$ ($r^2 = 0.87$)
Pod weight (g) and bark weight (g)	One-seeded	$y = 6.1888 + 0.7428x$ ($r^2 = 0.61$)
Pod width (cm) and bark weight (g)	One-seeded	$y = 9.4687 + 0.1523x$ ($r^2 = 0.60$)
Pod weight (g) and pod length (cm)	Two-seeded	$y = 11.336 + 0.039x$ ($r^2 = 0.61$)
Pod weight (g) and bark weight (g)	Two-seeded	$y = 11.839 + 0.9006x$ ($r^2 = 0.88$)
Pod length (cm) and pod width (cm)	Three-seeded	$y = 8.6735 + 0.7363x$ ($r^2 = 0.65$)
Pod weight (g) and pod length (cm)	Four-seeded	$y = 9.8776 + 0.0478x$ ($r^2 = 0.66$)
Pod weight (g) and total seed weight (g)	Four-seeded	$y = 2.6385 + 0.2481x$ ($r^2 = 0.77$)
Pod length (cm) and total seed weight (g)	Four-seeded	$y = 10.377 + 0.1709x$ ($r^2 = 0.67$)
Pod length (cm) and pod width (cm)	Four-seeded	$y = 1.798 + 1.227x$ ($r^2 = 0.51$)
Pod length (cm) and bark weight (g)	Four-seeded	$y = 9.87776 + 0.0478x$ ($r^2 = 0.51$)
Bark weight (g) and total seed weight (g)	Four-seeded	$y = 11.319 + 0.2828x$ ($r^2 = 0.53$)

Relationship among growth characteristics of *Plukenetia conophora* seedlings from different pod-size classes three weeks after emergence

There was significant difference in the stem height of the different pod-size classes with four-seeded pods having the tallest (82.93 cm) plants and one-seeded pods having the shortest (36.16 cm) (Table 4). Stem girth increased with increasing seed number per pod and were all significantly different except for between three- and four-seeded pods. Mean number of leaves was highest in four-seed pods. However, total leaf area on the average was highest in seedlings raised from size class three.

The inter-relationship among the growth characteristics in seedlings raised from one seeded and two seeded pods were not significant after three weeks of emergence (Table 5). Significant relationship occurred between stem height (cm) and total number of leaves ($r^2 = 0.77$) in seedlings raised from three-seeded pods. In four-seeded pods, highly significant relationships occurred between stem girth (cm) and total number of leaves

(r^2 = 0.82); between stem height (cm) and stem girth (cm) (r^2 = 0.79) and between stem height and total number of leaves (r^2 = 0.94). The predictive equations of the significant relationships among the growth characteristics are presented on Table 5. The significant relationship shows that one parameter can be deduced from another.

Table 4: Growth performance of *Plukenetia conophora* seedlings three weeks after emergence

Pod-size class	Stem Height (cm)	Stem girth (cm)	No. of leaves/plant	Leaf area (cm^2)
One-seeded	36.16	2.05	2.60	92.98
Two-seeded	39.69	4.85	6.40	111.12
Three-seeded	65.96	6.39	7.13	127.64
Four-seeded	82.93	7.21	9.27	123.59
LSD ($p \leq 0.05$)	21.03	1.58	2.20	19.91

LSD = Least significant difference at $p \leq 0.05$

Table 5: Predictive equations of significant relationships among the growth characteristics of seedlings raised from seeds obtained from different pod-size classes within the first three weeks of growth

Inter-relationships	Pod-size class	Predictive equation
Total seed weight (g) and stem girth (cm)	Three	$y = 3.053 + 0.051x$ ($r^2 = 0.56$)
Stem height (cm) and total number of leaves	Three	$y = 1.994 + 0.078x$ ($r^2 = 0.77$)
Stem girth (cm) and total number of leaves	Three	$y = 0.755 + 0.999x$ ($r^2 = 0.58$)
Stem height (cm) and stem girth (cm)	Four	$y = 1.213 + 0.072x$ ($r^2 = 0.79$)
Stem height (cm) and total number of leaves	Four	$y = 1.126 + 0.098x$ ($r^2 = 0.94$)
Stem girth (cm) and total number of leaves	Four	$y = 1.133 + 1.128x$ ($r^2 = 0.82$)

Relationship among growth characteristics of *Plukenetia conophora* seedlings from different pod-size classes fifteen weeks after emergence

At 15 weeks after emergence, one- and two-seeded pods were significantly shorter than the three- and four-seeded pods (Table 6). Stem girth and number of leaves also increased as seed number per pod increased. Significant differences occurred among one-, two- and three-seeded pods but there was no significant difference between three- and four-seeded pods. Total leaf area (cm) was higher in seedlings raised from four-seeded pods than those raised from three-seeded pods (Table 6).

Table 6: Growth performance of *Plukenetia conophora* seedlings 15 weeks after emergence

Pod-size class	Stem height (cm)	Stem girth (cm)	No. of leaves/ plant	Leaf area (cm^2)
One-seeded	36.16	2.05	2.60	92.98
Two-seeded	39.69	4.85	6.40	111.12
Three-seeded	65.96	6.39	7.13	127.64
Four-seeded	82.93	7.21	9.27	123.59
LSD (0.05)	21.03	1.58	2.20	19.91

LSD = Least significant difference at $p \leq 0.05$

Nutritional composition of raw and cooked seeds of *Plukenetia conophora*

Raw and cooked seeds of *P. conophora* are rich in protein, fibre and fat. However, cooking had effect on these nutritional compositions (Table 7). The nuts of *P. conophora* are rich in vitamins A, C and E and in minerals such as potassium, sodium, calcium and magnesium. However, cooking reduced their values with vitamin C been the most affected, from 62.44mg/100g in raw seeds to 35.71mg/100g in boiled seeds (Table 7).

Table 7: Nutritional composition of raw and boiled nuts of *Plukenetia conophora* on dry yield basis

Nutrient composition	Raw seeds	Boiled seeds
Proximate Composition (%)		
Dry matter	87.38	89.14
Fat yield	38.47	37.54
Ash	3.53	3.11
Crude protein	27.18	26.48
Crude fibre	5.21	5.15
Vitamin Content (mg/100g)		
Vitamin A	62.44	35.71
Vitamin C	45.76	28.16
Vitamin E	24.83	20.33
Mineral Content (mg/100g)		
Potassium	408.33	395.00
Sodium	180.00	138.67
Calcium	49.43	46.76
Magnesium	106.40	103.20

Discussion

The morphological characteristics of *P. conophora* showed that the pod weight is proportional to the seed number. Pod length and pod width among the different size-classes showed a minimal difference in shape. The results showed that *P. conophora* has thick pod bark, which contributed to the pod weight, while the contribution of seed weight to pod weight was significant in four-seeded pods. However, as the number of seeds increase from 3 to 4, the contribution of the bark to the overall pod weight tended to reduce. The total seed weight in four-seeded pods was higher than in other pod size-classes.

The inter-relationship among the morphological characteristics of the pods showed that some characteristics could be predicted from others. The results of the predictive equation of the significant relationships among the morphological characteristics of various pod size-classes of *P. conophora* showed that the weight of the pod is an important characteristic that could be used in determining most of the other morphological characteristics.

The least growth was recorded for mean stem girth while the highest growth was recorded for mean stem height three weeks after emergence. Three weeks after emergence, seedlings raised from 4-seeded pods were the tallest, followed by 3-seeded pods, while the least height growth was recorded in 1-seeded pod. This pattern continued up to 15 weeks after emergence. This shows that *P. conophora* is a fast growing climber in terms of height.

The result of the predictive equation of the morphological characteristics measured three weeks after emergence showed that total number of leaves could be predicted from stem height or stem girth. The proportionate relationships could be attributed to the large numbers of leaves and their photosynthetic ability which provide the photosynthate for stem height and stem girth growth. Thus, the number of leaves could be easily predicted from the stem height. This shows that the parameters were controlled by the same growth factors (Akachuku, 2001)

The growth parameters of *P. conophora* seedling 15 weeks after emergence were not statistically significant among the different pod-size classes. This shows that increase in a particular growth characteristic did not necessarily result in proportionate growth in another growth characteristic as the plant age increased.

The high protein content (26.48%) of the cooked seeds showed that it could serve as a good source of protein as it compares favourably with other protein sources such as beans and meat. Various authors have given the protein values of beans (*Phaseolus vulgaris* L.), however, the value given varies from 11.0% to 31.59% on dry yield basis. The variation might be as a result of differences in geographical location, variety and the processing method used (Sanni *et* al., 1999; Oliveira *et al*., 2008 and Brigide *et al*., 2014). The protein content of African yam beans (*Sphenostylis stenocarpa*) was also reported by Ndidi *et al*. (2014) as 21.78%, 19.74% and 20.47% for raw, boiled and roasted samples, respectively. Williams (2007) reported protein content of 20-25 g/100g for raw red meat and 28-36 g for cooked red meat. The average protein composition (per 100g) of the lean component of red meat such as beef (23.2 g), veal (24.8 g), lamb (21.9 g) and mutton

(21.5g) was also reported. The presence of protein, which is one of the most important nutrients needed by the body, in *P. conophora* makes it a good protein source.

The consumption of *P. conophora* nuts provides vitamins and minerals in appreciable amounts. Vitamins such as vitamins A, C, E and carotene present in the nut possess antioxidant properties which reduce oxidation and counter the damaging effects of free radicals in the body and prevent oxidation process. Thus, by virtue of their properties, they can delay ageing process. They also prevent degeneration in blood vessels, heart, joints and the lenses of the eyes (McFarland, 2003; Simester, 2006).

Nutritional deficiencies occur in the intense processing such as cooking and refining of foods (Bakhru, 2010). This results in a colossal loss of vitamins, minerals and other nutrients and is responsible to a large extent for the vast array of present day diseases. Our forest food resources, often referred to as Edible Non-Timber Forest Products (E-NTFPs) are richer in vitamins, minerals and other nutrients than our staple foods such as cassava, yam, maize, rice, etc. It is therefore important to supplement our staple foods with our forest food resources.

Conclusions and Recommendations

The result obtained showed that on the average, pod weight, length and width of pod increased with increasing number of seeds per pod. Seedlings raised from four-seeded pods on the average had the highest stem height, while the seedlings raised from one-seeded pods were the shortest. In terms of growth, the seeds from four-seeded pod-size class performed better in terms of leaf number per plant and stem height. It is therefore advisable to select seeds for sowing from four-seeded pods. The nuts are rich in nutrient composition with crude protein content of 27.18% and crude fibre of 5.21% and compares favourably with the protein values of beans and meat. Thus, the nut could serve as a very good food supplement. Also, it has high fat content of 38.47%, could be extracted for industrial purposes. Therefore, its consumption is recommended. The propagation and further studies on other utilization products of the species should be encouraged by government, private agencies and individuals.

References

Akachuku, C. O. (1996). *Ex-situ* conservation and utilization of forest food plant species in South-Eastern Nigeria. Paper presented at the 5th annual scientific conference of Biological Society of Nigeria. Held at Federal University of Agriculture, Umudike from 6th – 10th October, 1996. 7pp.

Akachuku, C. O. (2001). Growth of bitter leaf (*Vernonia amygdalina*, Del. Compositeae) and nutritive values of its processed and unprocessed leaves. Discov.innov.,0001; 13(3/4):227-233.

Akachuku, C. O. (2005). Fruit Characteristics and Performance of African star Apple (*Gambeyaalbida* syn. *Chrysophyl lumalbidum*) at early stages of its growth. Journal of Agriculture, Agricultural Technology and Environment. A publication of the Faculty of Agriculture, University of Calabar 1(1): 97-104.

Anegbeh, P. O. and Ladipo, D. O. (1994). Growth of *Dacryodesedulis* grown on acid soils of Onne at varying ages. Paper presented at a regional workshop on "Improvement of *Dacryodesedulis*" 2nd –

7th October, (1994). Douala, Cameroon Metrological Station, Annual Report, 2005, Umudike.

AOAC (2005). Official Methods of Analysis of Association of Official Analytical Chemists (AOAC). 18th Ed. Published by the Association of Official Analytical Chemists International, Gaithersburg, Maryland, USA.

Awodoyin, R. O., Egunjobi, K. K. and Ladipo, D. O. (2000). Biology, germination and prospects for the domestication of the conophor nut, *Plukenetia conophora* Mull.Arg. [Syn. *Tetracarpidium conophorum* (Mull. Arg.) Hutch. & Dalz.]. *Journal of Tropical Forest Resources* 16(1): 30-38.

Ayua, I. A. and Ajai, O. (1997). Implementing the biodiversity convention: Nigerian and African Perspectives. Nigerian Institute of Advanced Legal Studies (NIALS), 44:7.

Bakhru, H. K. (2010). Vitamins that Heal-Natural Immunity for Better Health. Published by Orient Paper Backs. New Delhi, India, 216pp.

Brigide, P., Canniatt-Brazaca, S. G. and Silva, M. O. (2014). Nutritional characteristics of biofortified common beans: Food Sci. Technol (Campinas) 34(3), Campinas July/Sept 2014. Online version: http://dx.doi.org/10.1590/1678-457x.6245

Denton, L and Ojeifo, I. M. (1993). Neglected vegetable crop species in Nigeria: In: Lost crops of Nigeria, Implication for food security; (Eds.). Okojie, J. A. and Okali, D. U. U. University of Agriculture, Abeokuta, Abeokuta Conference Proceeding 3:95-112.

Gbile, Z. O. (1993). Historical and future prospects of lost crops: In: Lost Crops of Nigeria, Implications of Food Security (Eds.) Okojie, J. A. and Okali D. U. U. University of Agriculture, Abeokuta, Abeokuta Conference Proceedings, 3:294-316.

James, C. S. (1995). Analytical Chemistry of Foods. Chapman and Hall, New York, 178pp.

Keay, R. W. J. (1959). An outline of Nigeria Vegetation. Federal Ministry of Information, Lagos, pp. 8-9.

Lusigi, W. J. (1991). The role of indigenous vegetation in the conservation and maintenance of ecological stability in crop genetic resources of Africa.Vol. 1 ed. F. A. Here, Zean, N. G. and P. Pernino. IBPGR/UNEP/IITA/CNR. 1:171-176

McFarland, J. L. (2003). *Aging Without Growing Old*. Lake Mary, Florida: Siloam Press, p. .515.

Minn, D. B. and Boff, J. M. (2003).*Crude Fat Analysis*: In: Food analysis 3rd Edition. Kluweir Academic/Plamn Publishers, New York.

Ndidi, U. S., Ndidi, C. U., Olagunju, A., Muhammad, A., Billy, F. G. and Okpe, O. (2014). Proximate Antinutrients and Mineral composition of Raw and Processed (Boiled and Roasted) *Sphenostyylisstenocarpa* seeds from Southern Kaduna, Northwest Nigeria. International Scholarly Research Notices (ISRN) Nutrition. Volume 2014 (2014), Article ID 280837, 9pp. Online journal: http://dx.doi.org/10.1155/2014/280837

NRCRI (2005). National Root Crops Research Institute, Umudike, Meteorological and soil Division, unpublished reports of Abia State.

Ochang, O. (2005). Identification and quantification of honeys from various floral sources. *Journal of Agricultural and Food Chemistry*, 50(21): 5870-5877.

Ogunsua, A. O. and Adebona, M. B. (1983). Chemical Composition of *Tetracarpidium conophorum* (conophor nut).*Food Chem.* 10(3):173-177.

Okafor, J. C. (1981). Woody plants of nutritional importance in traditional farming system of the Nigerian humid tropic. Ph.D Thesis, Department of Forest Resources Management, University of Ibadan, Ibadan.

Okigbo, B. N. (1977). Neglected plants of Horticultural importance in traditional

farming systems of tropical Africa. *Acta Horticulturae* 53: 131-150.

Oliveira, V. R., Ribeino, N. D., Jose, E. and Londero, P. M. G. (2008). Nutritional and microbiological quality of common beans (*Phaseolus vulgaris* L.) cooked with or without the use of soaking water. Ciencia Agrotechnologia, 32(6): 1912-1918.

Pearson, D. (1976). *The Chemical Analysis of Food*. 7th ed. Edinburg; New York: Churchill Livingstone, 575pp.

Sanni, S. A., Oguntona, C. R. B., Sanni, L. O. (1999). Chemical and nutritional composition of some common foods in Abeokuta, Nigeria. Brazilian Archives of Biology and Technology, 42 (3): 331-338.

Simester, L. (2006). *The Natural Health Bible. Stay Well, Live Longer*. Charling Cross Road, London: Quadrille Publishing Limited, 288pp.

Williams, P. (2007): Nutritional composition of real meat. Nutrition and Dietetics, 64: S113-S119. Online paper: http//dx.doi:10-1111/d.1747.0080.2007.00197x.