JABU INTERNATIONAL JOURNAL OF AGRICULTURE AND FOOD SCIENCE VOLUME 9

IJAFS

JABU INTERNATIONAL JOURNAL OF AGRICULTURE AND FOOD SCIENCE

ISSN: 2141-7156

DECEMBER 2019

VOLUME 9

PROXIMATE COMPOSITION AND PHYTOCHEMICAL PROPERTIES OF *PARKIA BIGLOBOSA* (JACQ.)*R. BR. EX DON* SEEDS IN DERIVED SAVANNA ECOSYSTEM OF SOUTH-WESTERN NIGERIA

Oyerinde, V.O[1], Ifesan, B.O.T[2], Osakuade, A.A.,[1] and Oyerinde, A.S.[3]

1. Department of Forestry and Wood Technology, Federal University of Technology, P.M.B.704 Akure, Nigeria
2. Department of Food Science and Technology, Federal University of Technology, P.M.B.704 Akure, Nigeria
3. Department of Agricultural and Environmental Engineering, Federal University of Technology, P.M.B.704 Akure, Nigeria

Correspondence Author's Email: voyerinde@yahoo.com

Abstract

This study investigates the proximate composition and phytochemical properties of P. biglobosa seeds collected from three States (Osun, Ondo and Ekiti) in the derived savanna ecosystem of South-Western part of Nigeria. P. biglobosa seed samples were collected from ten trees with sufficient fruits and without visible insect damage or disease symptoms on agroforestry farms in six communities within the study area. The seeds were removed manually and milled into flour for analyses (proximate composition, phytochemical and antioxidant properties) using standard methods. The results revealed that there were no significant differences (p >0.05) in the the protein contents (37.31%-39.84%) of the seeds from the three states. Tannin content of P. biglobosa seeds from Ondo State (5.00g/100g) was significantly higher than those from Osun and Ekiti States. Alkaloid contents from the seeds ranged from (4.44 g/100g-4.90 g/100g) and it was observed that the phytate content of seeds from the states were significantly different. P. biglobosa seeds from Ekiti State were found to possess highest value of total phenol (27.44 g/100g) and total flavonoid (4.27 g/100g) while the sample from Ondo State exhibited highest vitamin C content (62.41 g/100g). The ability of the samples to scavenge DPPH radical was highest in Ondo State sample (78.35%) which may be attributed to the vitamin C content. The result is an indication that further studies should be carried out to investigate the application of seeds of P. biglobosa as an ingredient in functional foods.

Keywords*:* AntioxidantProperties, *P. Biglobosa*, Proximate Composition, Phytochemical Properties

IJAFS 2019, (4), 9:1285-1292
Accepted for publication
May, 2019

Introduction

Tropical forests provide ample goods and services; these mainly include timber and non-timber forest products (NTFPs). The non-timber forest products (NTFPs) play important roles in rural community around the world (Onyekwelu *et al.*, 2015). Examples of NTFPs include; *Blighia sapida (*K.D Koenig), *Parkia biglobosa* (Jacq.) R. Br. ex Don, *Garcinia kola (*Heckel), *Cola nitida* (Vent.) Schott, *Irvingia gabonensis* (Aubrey-Lecomte ex O.Rorke) *Ricinodendron heudelotti* (Baill.) and *Chrysophyllum albidum* (Linn) have provided domestic importance to rural and urban dwellers, with great export potentials (Nwoboshi, 2000). These NTFPs are highly valued by rural people and form part of their daily diet. They could be essential sources of proteins, vitamins and minerals thus making them nutritionally important (Sacande and Clethero, 2007).

Parkia biglobosa, commonly known as African locust beans, is an important multipurpose tree and one of the most common species of the parkland agroforestry system (Onyekwelu *et al.*, 2015). The importance of *P.*

biglobosa to human livelihoods had been reviewed (Kalinganire, *et al.*, 2008; Teklehaimanot, 2007). The seeds are rich in protein and usually fermented to a

tasty food condiment called *'iru' or 'dawadawa'* which is used as a flavour intensifier for soups and stews and also adds protein to a protein-poor diet (Dike and Odunfa, 2003). However, the use of African locust bean seeds and other legumes as protein source is limited by the presence of anti-nutritional factors, which cause poor protein digestibility and are capable of precipitating other deleterious effects (Esenwah and Ikenebomeh, 2008).

Recent studies have shown that the leaf, seed and bark of *P. biglobosa* are possess some phytochemicals and exhibited antioxidant properties (Adaramola *et al*., 2013; Komolafe and Oyelade, 2015). *P. biglobosa* is an important woody plant used in traditional medicine (Olorunmaiye *et al*., 2011). The roots, barks, leaves, stems, flowers, fruits and seeds of *P. biglobosa* are used medicinally to treat a range of ailments, including diarrhoea, ulcers, pneumonia, burns, coughs and jaundice (Sacande and Clethero, 2007). In addition, Akoma *et al*., (2001) revealed that, the fruit pulp of *P. biglobosa* is sweet to taste, which indicates the presence of natural sugar and thus, a potential energy source. It also possesses an attractive yellow colour revealing the presence of carotenoid and sour taste which shows the presence of ascorbic acid (Gernah, *et al*., 2007).

However, little scientific information is available on proximate composition and phytochemical properties of *P. biglobosa* as influenced by seeds collected from different geographical locations within the derived savanna ecosystem of Southwest, Nigeria. Therefore, the determination of proximate composition, antioxidant and phytochemical properties of the seeds across geographical locations where there are abundance of the trees and fruits are essential in order to ascertain variation that may exist in their chemical constituents.

Materials and Methods

Sample collection

The samples were collected from three States (Osun, Ondo and Ekiti States) in the derived savanna ecosystem in Nigeria and purposively selected for abundance of the trees and availability of fruits. The sample trees used for this study were selected using multi-stage sampling technique. One local government area (LGA) was selected from each of the states and two towns were picked from the selected LGA. Samples were collected from ten *P. biglobosa* trees in each of the selected communities (making a total of 60 trees) with sufficient fruits and without visible insect damage or disease symptoms.

Sample preparation

The fruit pods were split open and the pulp washed with water to extract the seeds. The extracted seeds were washed with distilled water and sun-dried. The seed samples were finely milled into flour with the aid of a mechanical blender and sieved using 25 mm sieve prior to chemical analyses.

Determination of proximate composition of Parkia biglobosa seeds

The moisture, crude protein, crude fat, fibre and ash contents were determined according to the method of Association of Official Analytical Chemists (2005). Carbohydrate content was calculated by difference method described by Pearson (1976).

Determination of phytochemical properties of Parkia biglobosa seeds

Tannin content determination

0.2 g of finely ground sample was weighed into a 50 ml sample bottle. Ten milliliters of 70% aqueous acetone were added and properly covered. The bottles were put in an ice bath shaker and shaken for 2 h at 30^0C. Each solution was then centrifuge and the supernatant stored in ice. 0.2 ml of each solution was pipetted into the test tube and 0.8ml of distilled water was added. Standard tannic acid solutions were prepared from a 0.5 mg/ml of

the stock and the solution made up to 1 ml with distilled water. About 0.5 ml of Folin Ciocateau reagent was added to both samples and standard followed by 2.5 ml of 20% Na_2CO_3 the solution was then vortexed and allowed to incubate for 40 min at room temperature. Its absorbance was read at 725 nm against a reagent blank. Concentration of the same solution from a standard tannic acid curve prepared (Makkar and Goodchild, 1996).

Oxalate content determination

Oxalate was determined by soaking 1g of the sample in 75 ml of 1.5M H2SO4for 1h and then filtered through a No 1 Whatman filter paper. 25 ml was taken out of the filtrate and poured inside a conical flask and this was titrated hot about (80-90^{o}C) against 0.1M $KMnO_4$ until a pink colour that persist for 15 sec was attained (Day and Underwood, 1986).

Saponin content determination

The spectrophotometric method of Brunner (1994) was used for saponin determination. Two grams of the finely ground sample was weighed into a 250 ml beaker and 100 ml of Isobutyl alcohol was added. The mixture was shaken for 5 hours to ensure uniform mixing. The mixture was filter with No 1 Whatman filter paper into 100 ml beaker containing 20 ml of 40% saturated solution of magnesium carbonate ($MgCO_3$). The mixture obtained was again filtered though No 1 Whatman filter paper to obtain a clean colourless solution. 1 ml of the colourless solution was taken into 50 ml volumetric flask using pipette while 2 ml of 5% iron (III) chloride ($FeCl_3$) solution was added and made up to the mark with distill water. It was allowed to stand for 30 minutes for the colour to develop. The absorbance was read against the blank at 380 nm.

Phytate content determination

Phytates were determined according to the method used by Ramadan (2012). 4g of sample was soaked with 100 ml of 2% HCl for 3 hours and then filtered through a No 1 Whatman filter paper. 25 ml was taken out of the filtrate and poured inside a conical flask and 5 ml of 0.3% of ammonium thiocyanate solution was added as indicator, after which 53.5 ml 0f distilled water was added to give it the proper acidity and this was titrated against 0.00566 g per milliliter of standard iron (III) chloride solution that contained about 0.00195 g of iron per ml until a brownish yellow colouration persist for 5 minutes.

Determination of alkaloid content

The alkaloid content was determined gravimetrically using the methods of Harbone (1984). Five grams of each sample was weighed and dispersed into 50 ml of 10% acetic acid solution in ethanol. The mixture was then allowed to stand for about 4 h before it is filtered. This was filtered and extract was concentrated on a water bath to one quarter of the original volume. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre-weighed filter paper was used to filter off the precipitate and washed with 1% ammonium hydroxide solution. The weight of the alkaloid was expressed as a percentage of the sample weight analyzed.

Determination of antioxidant properties of Parkia biglobosa seeds.

Vitamin C content determination

Vitamin C content of the aqueous extract of sample was determined using the method of Benderitter et al., (1998). Two gram of dinitrophenyl hydrazine (DNPH; 230 mg thiourea and 270 mg CuSO4.5H2O in 100ml of 5 M H2SO4) was prepared and 75 µl of it was added to 500 µl reaction mixtures [300µl of the aqueous extracts and 100 µl of 13.3 % trichloroacetic acid (TCA)]. The reaction mixture was subsequently incubated for 3 h at 37°C, then 0.5 ml of 65% H2SO4 (v/v) was added to the medium and the absorbance was measured at 520 nm.

Determination of total phenol content

The total phenol content of the methanol extracts of *P. biglobosa* was determined using the method reported by Singleton *et al*. (1999). Appropriate dilutions of the extracts were oxidized with 2.5 ml of 10% Folin Ciocalteau's reagent and neutralised by 2.0 ml of 7.5% sodium carbonate. The reaction mixture was incubated at 45°C for 40 mins, and the absorbance was measured at 765 nm with the JENWAY Model 6305 UV-Visible spectrophometer (Barlworld Scientific, Dunmow, United Kingdom). The total phenol content was calculated using Gallic acid as standard.

Determination of free radical scavenging capacity (DPPH TEST)

The free radical scavenging ability of the methanol extracts of *P. biglobosa* against DPPH (1, 1- diphenyl-2picryhydrazyl) free radical was evaluated as described by Hutadilok-Towatana *et al.,* (2006). An appropriate dilution of the extract (1 ml) was mixed with 1 ml of the 0.4 mM methanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min before measuring the absorbance at 516 nm. The DPPH free radical scavenging ability was calculated with respect to the reference (which contains all the reagents without test sample). Free radicals scavenging ability was expressed as percentage (%) inhibition:

$$(AA\ \%) = \frac{\text{absorbance of control} - \text{absorbance of extract}}{\text{absorbance of control}} \times 100 \quad (2)$$

Determination of flavonoid

The ethyl acetate precipitation method was used by Bohm and Kocipai-Abyazan (1994). Five grams of sample was hydrolyzed by boiling in 100 ml of 2 ml of hydrochloric acid solution for about 35 min. The hydrolysate was filtered to recover the extract (filtrate). The filtrate was treated with ethyl acetate drop wise twice until in excess. The precipitated flavonoid was recovered by filtration using a weighed filter paper. After drying in the oven at 100°C for 30min, it was cooled in a desiccator and reweighed. The difference in weight gave the weight of flavonoid which was expressed as a percentage of the weight of sample analyzed.

Methods of data analysis

Data were subjected to analysis of variance (ANOVA). Comparison of means was carried out by Duncan's multiple range tests. Statistical analysis was performed using the Statistical Package for Social Sciences package (SPSS 16.0). All experiments were determined in triplicates and means ± SE were calculated from triplicate determination.

Results and Discussion

Proximate compositions of P. biglobosa seeds

The proximate compositions of *P. biglobosa* flour across the states are presented in Table 1. The protein contents were 41.88% for Ekiti State, 43.19% in Ondo State sample and 47.38% for seeds collected from Osun State. Appiah *et al*. (2012) reported values lower than 49.69% in condiments but higher than the values (33.64%) for raw seeds (Ijarotimi and Keshinro, 2012). The protein contents of the seed supported earlier submissions of Yusuf *et al*. (2007) that, *P. biglobosa* is a major source of plant protein and fat. It is a reliable source of nutrient used in combating protein deficiency among the rural poor in Nigeria. The fat content of seed samples differs significantly among the state, with 20.46% from Ondo State, (18.07 %) from Ekiti State and (16.60 %) from Osun State.

Table 1: Proximate composition (Mean ± SE) of *P. biglobosa* seeds (%dwb)

Sample	Osun	Ekiti	Ondo
Protein	47.38±0.54^{a}	41.88±1.14^{c}	43.19±0.56^{b}
Fat	16.60±0.50^{c}	18.07±0.15^{b}	20.46±0.29^{a}
Ash	6.04±0.16^{b}	6.77±0.08^{a}	5.62±0.35^{b}
Fibre	10.73±0.23^{b}	10.15±0.13^{b}	11.10±0.09^{a}
Carbohydrate	19.15±0.23^{b}	20.96±0.78^{a}	20.25±0.65^{ab}

Mean values with the same superscript in a row are not significantly different (P > 0.05). Each value is a mean of three replicate ±SE.

Similarly, the ash content of the Ekiti State sample (6.77%) was higher than those of Osun and Ondo States (6.04% and 5.62%), respectively. The ash content of *P. biglobosa* (5.62%-6.77%4 -) among the states was within the range of some legumes (2.00% in peas and 5.00% in *Glycine max* (Onyekwelu *et al.*, 2015). The fibre contents of samples from both Osun and Ekiti States (10.73%; 10.15%), respectively were lower and significantly different ($p < 0.05$) when compared with the sample from Ondo State (11.10 %). The crude fibre was found to be lower than the value (18.00%) reported by Gernah et al. (2007*)*. Crude fibre is a source of dietary fibre which is essential for good bowel movement and helps to prevent obesity, diabetes, cancer of the colon, reduce level of cholesterol in the body in order to minimize risks of cardiovascular diseases and another ailment of the gastrointestinal tract of human (Okaraonye and Ikewuchi, 2009; Onyekwelu *et al.*, 2015). The values obtained for protein, fat, moisture and ash contents from this study were similar to the values reported by Elemo *et al*. (2011).

Phytochemical properties of P. biglobosa seeds

Table 2 revealed the phytochemical properties of the *P. biglobosa* seed obtained from the trees across the study area. The result indicated that there were significant differences in the phytochemical properties of the seeds among the States except for alkaloid content. It was observed that the seeds possessed high level of phytate compared with other phytochemicals. The concentration of the phytate was lowest in the sample from Osun State (6.86 g/100g), followed by seeds from Ekiti State (8.24 g/100g) and highest in seeds from Ondo State (9.61 g/100g).

Table 2: Phytochemical properties (g/100g**) of *P. biglobosa* seeds (**g/100g**)**

Properties	Osun	Ekiti	Ondo
Tannin	2.71±0.02^{b}	2.91±0.01^{b}	5.00±0.02^{a}
Alkaloid	4.45±0.15^{a}	4.44±0.26^{a}	4.90±0.10^{a}
Oxalate	1.40±0.03^{b}	1.60±0.03^{a}	1.57±0.03^{b}
Phytate	6.86±0.27^{c}	8.24±0.48^{b}	9.61±0.27^{a}
Saponin	2.67±0.01^{a}	2.04±0.01^{b}	2.16±0.17^{c}

Mean values with the same superscript in a row are not significantly different (P > 0.05). Each value is a mean of three replicates ± standard error.

The presumed anti-nutrient effect of phytic acid may be more relevant to developing nations where diets are relatively deficient in micronutrients. On the contrary, in developed nations like the United States, where the diet is predominantly meat-based and relatively well balanced in terms of micronutrients, phytic acid consumption is considered beneficial to public health (Bohn *et al*., 2008). In addition, phytic acid (inositol hexakisphosphate) has been proposed as a novel protective treatment for Alzheimer's disease (Anekonda, *et al.*, 2011). Alkaloid content was between 4.44 g/100 g and 4.90 g/100 g. Some common alkaloids are caffeine, nicotine, quinine, cocaine, and morphine. Alkaloids have been demonstrated to have microbicidal and antidiarrheal effect, which is probably due to their effects on transit time in the small intestine (Nkwocha, *et al.*, 2014). Alkaloids are known for their toxicity but not all alkaloids are toxic. Alkaloids have been reported to inhibit certain mammalian enzymatic activities such as, phosphodiesterase, which prolongs the action of cyclic adenosine monophosphate (Nkwocha, *et al.*, 2014). The values recorded for tannin concentration in *P. biglobosa* seeds from Ondo State were found to be significantly higher than those from Osun State (2.71 g/100g) and Ekiti State (2.91 g/100g).

The tannin contents of the seeds from Osun and Ekiti States were within the range reported by Ijarotimi and Keshinro (2012) for the raw seeds (2.10 g/100g). Tannin relevant to grazing ruminants has been reported to contribute to prevention of bloat and the suppression of internal parasites (Hoste *et al.*, 2006). Also, tannin belongs to polyphenol group which has been reported to act as antioxidant by preventing oxidative stress that causes diseases such as coronary heart diseases, some types of cancers and inflammation (Tapiero *et al.*, 2002). The saponin content of the sample among the States was 2.67 g/100g for Osun, Ekiti (2.04 g/100g), and Ondo State (2.16 g/100g). This showed that the saponin content of *P. biglobosa* was not as high as that of soybean (2.20-5.83 g/100g) as reported by MacDonald *et al.*, (2005). Clinical studies have suggested that saponin affect the immune system in ways that help to protect the human body against cancers and also lower cholesterol levels. Saponin decrease blood lipids, lower cancer risks, blood glucose response.

In addition, a high saponin diet can be used in the inhibition of dental caries and platelet aggregation, in the treatment of hypercalciuria in humans, and as an antidote against acute lead poisoning (Shi *et al.*, 2004). Oxalate content of the seeds from Ekiti State (1.60 g/100g) was statistically different from those obtained from both Ondo (1.57 g/100g) and Osun (1.40 g/100g) States. The oxalate content in this study was lower (3.57g/100g) than that reported for raw *Parkia biglobosa* seeds (Ijarotimi and Keshinro, 2012) and *Synsepalum dulcificum* pulp (5.67 g/100g) by (Nkwocha, *et al.*, 2014). Variations may be due to differences in climate, soil quality, state of ripeness and may be caused by the different methods used for measuring oxalate in food (Ijarotimi and Keshinro, 2012).

Antioxidant properties of P. biglobosa seeds

The mean total phenol content of *P. biglobosa* seeds varied from 20.56 GAE/ml in Osun State to 27.44 GAE/ ml in Ekiti State and higher than flavonoid content of seeds (2.81% - 4.27%). A variety of phenolic compounds such as flavonoids, anthocyanins, flavan-3-ols and phenolic acids present in Australian fruits have been found to contribute to antioxidant activity (Netzel *et al.*, 2007). Results further showed that raw *P. biglobosa* seeds possessed very high vitamin C content of 62.41 mg/g in Ondo State sample, 42.66 mg/g in Osun State seeds and 41.02 mg/g from Ekiti State. Polyphenol antioxidants are abundant in the diet and have the potential to prevent diseases caused by oxidative stress, including neuro-degenerative and cardiovascular diseases, cancer, and stroke (Wang and Brumaghim, 2011). The ability of the seeds to scavenge free radicals of DPPH was highest (78.35%) in *P. biglobosa* seeds from Ondo State, followed by 67.91% in Osun State sample and least (57.03%) from Ekiti State seeds.The antioxidant properties exhibited by phytochemicals from plant is achieved by preventing the production of free radicals or by scavenging free radicals produced in the body (Oboh *et al*., 2007).

Table 3: Antioxidant properties of *P. biglobosa* seeds

Antioxidant properties	Osun	Ekiti	Ondo
Total phenol (GAE/ml)	20.56±0.07^{c}	27.44±0.15^{a}	22.04±0.01^{b}
Vitamin C (mg/g)	42.66±0.19^{b}	41.02±0.20^{c}	62.41±0.25a
DPPH (%)	67.91±0.25^{b}	57.03±0.15^{c}	78.35±0.41^{a}
Total flavonoid (%)	2.81±0.25$_{b}$	4.27±0.20^{a}	3.20±0.19^{b}

Mean values with the same superscript in a row are not significantly different (P > 0.05). Each value is a mean of three replicates ± standard error.

Conclusions

Research findings obtained from *P. biglobosa* seeds investigated in this study supported the earlier findings that the raw seed is rich in protein and phytochemicals. Considering the differences in the chemical constituents of the seeds from different geographical location investigated in this work, *P. biglobosa* seed from Ondo State was found to possess tannin, alkaloid, phytate and vitamin C at levels significantly higher than other samples. In addition, the seed from Ondo State demonstrated highest radical scavenging activity which may be attributed to variations in climate and soil quality.

References

Adaramola, T. F., Ariwaodo, J. O. & Adeniji K. A. (2013). Distribution, Phytochemistry and Antioxidant Properties of the Genus *Parkia* R.br. (Mimosaceae) in Nigeria.*International Journal of Pharmacognosy and Phytochemical Research* 4: 172-178.

Akoma, O., Onyoha, S. A., Akoma, A. O. & Ozigis, A. A. (2001). Physicochemical attributes of wine produced from the yellow pulp of *Parkiabiglobosa* using traditional juice extraction technique. *Nigerian Food Journal* 19: 76–79.

Anekonda, T. S., Wadsworth, T. L., Sabin, R., Frahlera, K., Harris, C., Petrikoa, B., Ralled, M., Woltjere, R. & Quinna, J. F. (2011). Phytic Acid as a Potential Treatment for Alzheimer's Pathology: Evidence from Animal and *in vitro* Models. *Journal of Alzheimer's disease* 23: 21–35.

Appiah, F., Oduro, I.Ellis, W. O. and Adu, G. (2012).Comparative assessment of the performance of *Parkia biglobosa*, *Glycine max* and *Treculia africana* in the production of a local condiment (dawadawa) in Ghana. *African Journal of Food Science* 6:111-116.

Bohm, B.A. & Kocipai- Abyazan, R. (1994). Flavonoid and condensed tannins from the leaves of *Vaccinum raticulation* and *Vaccinum calcyimium*.*Pacific Science* 48: 458-463.

Brunner, J. H. (1984). Direct Spectrophotometric determination of saponin. *Analytical Chemistry* 34: 1314-1326.

Day, R. A (Jnr) and Underwood, A. L. (1986). *Quantitative Analysis*.5th edn.Prentice-Hall Publication.pp 701.

Dike, E. N. and Odunfa, S. A. (2003). Microbiological and biochemical evaluation of a fermented soyabean product-soyadawadawa.*Journal of Food Science and Technology* 40: 606- 610.

Elemo, G. N., Elemo, B. O., Oladunmoye, O. O. & Erukainure, O. L. (2011). Comprehensive investigation into the nutritional composition of dehulled and defatted African locust bean seed (*Parkia biglobosa*). *African Journal of Plant Science* 5:291-295.

Esenwah, C. N. and Ikenebomeh, M. J. (2008). Processing Effects on the Nutritional and Anti-Nutritional Contents of African Locust Bean (*Parkia biglobosa* Benth.) Seed. *Pakistan Journal of Nutrition* 7: 214-217.

Gernah, D. I., Atolagbe, M. O. and Echegwo, C. C. 2007.Nutritional composition of the African Locust bean (*Parkia biglobosa*) fruit pulp.*Nigerian Food Journal* 25:190-196

Hoste, H., Jackson, F., Athanasiadou, S., Thamsborg S. M. and Hoskin S. O. (2006). The effects of tannin-rich plants on parasitic nematodes in ruminants.*Trends in Parasitology* 22: 253-261.

Ijarotimi, O. S. and Keshinro, O. O. (2012). Comparison between the amino acid, fatty acid, mineral and nutritional quality of raw, germinated and fermented African locust bean (*Parkia biglobosa*) flour.*ACTA Scientiarum Polonorum Technologia Alimentaria*, 11: 151-165.

Kalinganire, A. Weber, J. C., Uwamariya, A. and Kone, B. (2008). Improving Rural Livelihoods through Domestication of Indigenous Fruit Trees in the Parklands of the Sahel. In: Akinnifesi FK, Leaky RRB, Ajayi OC, Silesh G, Tchoundjeu Z, Matakala P, Kwesiga FR (eds.) *Indigenous Fruit Trees in the Tropics Domestication, Utilization and Commercialization*. Columns Design Ltd, Reading, UK. 186-203.

Komolafe, K. and Oyelade, W. (2015). Phytochemical Screening and *in vitro* Antioxidant Activity of *Parkia biglobosa* Extract. *Journal of Biology, Agriculture and Healthcare* 5:91-95.

MacDonald, R. S,, Guo, J. Y., Copeland, J,, Browning, J. D., Sleper, D,, Rottinghaus, G. E & Berhow, M. A. (2005). Environmental influences on isoflavones and saponins in soybeans and their role in colon cancer. *Journal of Nutrition* 135: 1239-1242.

Makkar, A. O. S. & GoodChild, A. V. (1996). *Quantification of Tannins: A laboratory Manual*. Aleppo, Syria: International Centre for Agriculture Research in the Dry Areas (ICARDA); 25pp.

Netzel, M., Netzel, G., Tian, Q., Schwartz, S. and Konczak, I. (2007). Native Australian fruits-a novel source of antioxidants for food. *Innovative Food Science Emerging Technology* 8: 339-346.

Nkwocha, C. C., Njoku, O. U. and Ekwueme, F. N. (2014). Phytochemical, Antinutrient and Amino Acid Composition of *Synsepalum dulcificum* Pulp.*International Journal of Pharmacy and Biological Sciences* 9:25-29.

Nwoboshi L.C. (2000). *The nutrient factor in sustainable forestry*. Ibadan University Press. 303pp.

Oboh, G., Puntel, R.L. and Rocha, J.B.T. (2007). Hot pepper (*Capsicum annuum*, Tepin and *Capsicum Chinese*, Habanero) prevents Fe2+-induced lipid peroxidation in Brain: *in vitro*. *Food Chemistry* 102: 178-185.

Okaraonye, C. C. and Ikewuchi, J. C. (2009). Nutrition and Anti-nutritional Components of *Pennisetum ipnpureum Schmach*.*Pakistan Journal of Nutrition* 8: 32-34

Olorunmaiye, K. S., Fatoba, P. O., Adeyemi, O. C. and Olorunmaiye, P. M. (2011). Fruit and seed characteristics among selected *Parkia biglobosa* (JACQ) G. Don.Population. *Agriculture and Biology Journal of North America* 2: 244-249.

Onyekwelu, J. C., Oyewale, O., Stimm, B. and Mosandln, R. (2015). Antioxidant, Nutritional and Antinutrition composition of *Garcinia kola* and *Chysophyllum albidium* from Rainforest Ecosystem of Ondo State, Nigeria.*Journal of Forestry Research* 26: 417-424.

Ramadan, E.A. (2012). Effect of processing and cooking methods on the chemical composition, sugars and phytic acid of soy beans.*Food and Public Health* 2: 11-15.

Sacande, M. and Clethero, C. (2007). Parkia biglobosa (Jacq.) G. Don. Millennium Seed Bank Project Kew.*Seed Leaflet* 124:3pp.

Shi, J. I., Arunasalam, K., Yeung, D., Kakuda, Y., Mittal, G. and Jiang, Y. (2004). Saponins from edible legumes: chemistry, processing, and health benefits. *Journal of Medicinal Food* 7: 67-78.

Singleton, V. L, Orthofer, R. and Lamuela-Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of *Folin-Ciocalteu* reagent. *Methods* in *Enzymology* 299: 152-178.

Tapiero, H., Tew, K. D., Ba, G. N. and Mathé, G. (2002). Polyphenols: do they play a role in the prevention of human pathologies? *Biomedicine and Pharmacotherapy*56: 200-207.

Wang, H. C. & Brumaghim, J. L. (2011). Polyphenol Compounds as Antioxidants for Disease Prevention: Reactive Oxygen Species Scavenging, Enzyme Regulation, and Metal Chelation Mechanisms in *E. coli* and Human Cells. *In: Oxidative Stress, Diagnostics, Prevention, and Therapy* 5: 99–175.