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Evaluation of Nutritional and Anti-Nutrional Profiles of Gingerbread Plum (*Neocarya Macrophylla*) Seed Kernel from Sokoto State, Nigeria

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ABSTRACT

The proximate, minerals, amino acids and anti-nutritional compositions of gingerbread plum (*Neocarya macrophylla*) seeds were evaluated. The results of proximate analysis showed a composition of 12.55% moisture, 5.52% ash, 23.24% crude protein, 7.67% crude fiber, 50.50% crude lipid, 6.04% available carbohydrate and 571.62kcal of energy value. The seed is rich in both macro and micro minerals element of which magnesium (503.08mg/100g), potassium (489.12mg/100g), calcium (312.55mg/100g) and sodium (78.76mg/100g) are the dominant macro elements, while iron (20.55mg/100g) is the dominant micro element present. The amino acids profile of the seed shows that for adult human the seed can supply the body with the required essential amino acids but for children the seed is deficient of leucine, lysine and threonine. The anti-nutrients to nutrients molar ratio show the deficiency of iron and zinc due to phytate. The result shows that the seed of *Neocarya macrophylla* if properly utilized could be used as a potential source of nutrients.

Key words: N*utritional, Anti-Nutritional, Seed Kernel, Neocarya Macrophylla*

1. INTRODUCTION

In Nigeria, wild fruits are commonly consumed by both rural and urban dwellers especially during the dry season when most cultivated fruits are out of season. Wild and semi wild food resources are frequently consumed as the dominant source of fruits especially in rural communities (Umar *et al*. 2007). Such wild fruits have helped to provide a steady supply of fruits during the dry season when cultivated fruits are scarce and expensive for low-income earners that traditionally have large family.

Fruits are important sources of nutrients which include carbohydrates, fiber, oils, proteins, minerals, antioxidant phenols, and vitamins which are essential for normal growth and development of body tissues for the human health. In addition, it is known that some fruits have so called "anti-nutritional" factors such as phytate, tannins, and oxalate that can diminish the nutrient bioavailability, especially if present if present at high level (Ali and Deokule, 2009). Although, it has been reported that these anti-nutritional factors could help to prevent and treat several diseases; remarkably, the anti-carcinogenic activity of phytate, and the anti-diarrheal activity of tannins (Spiller, 2001). Plant foods are the only sources of dietary fiber which plays an important role in decreasing the risk of many disorders such as constipation, diabetes, cardiovascular diseases, and obesity (Spiller, 2001). Plant polyphenols are known for lowering the risk of several oxidative stresses including cardiovascular diseases, cancer, stroke and ageing (Motlhanka *et al*., 2012).

Gingerbread plum (*Neocarya macrophylla*) commonly known as "*Gawasa*" in hausa language belongs to *Chrysobalanaceae* family. It is grown in arid and semiarid regions mainly in the Western part of Africa. The plant is semi-cultivated in Northern part of Nigeria and its fruits are harvested from the ground (Amza *et al*., 2011). The fruits are used in variety of ways. Many are eaten fresh or boiled with cereals. Fragrant syrups are prepared and proved to be much stronger than some fruit juice (Amza *et al*., 2011).

Previous studies have reported the nutritional profiles of gingerbread plum (*Neocarya macrophylla*) fruits (Cook *et al*., 20000; Audu *et al*., 2005). However, detail analyses of the nutrients content of the seed kernel of gingerbread plum (*Neocarya macrophylla*) obtained from Sokoto State, Nigeria is yet to be reported. Therefore, this study is aim to determine the nutritional and anti-nutritional profiles of gingerbread plum (*Neocarya macrophylla*) seed kernel in other to provide information on its potential as source of nutrient supplement.

2. MATERIALS AND METHODS

2.1. Sampling and Sample treatment

Fresh fruits of *Neocarya macrophylla* were collected from Wamakko Local government, Sokoto State, Nigeria. Five (5) trees were randomly selected and only ripped fruits were collected from different branches of the trees, as described by Hassan and Umar (2004). The sample was collected in black polythene bags and transported to laboratory. Prior to analyses, the sample was authenticated at the Herbarium section, Botany Unit, Usmanu Danfodiyo University, Sokoto, Nigeria. Representative sample was taken using alternate shovel method (Alan, 1996). The sample was thoroughly washed with distilled water and then air dried. The kernels were removed manually using hammer, pulverized to fine powder and used for the analyses (Nordeide *et al*., 1996).

2.2. Proximate Analysis

Standards methods of AOAC (1990) were used for the proximate analysis. The moisture content was determine by weighing two grammes (2g) of fresh seed kernel in a crucible and dried in an oven (Gallenkamp, UK) at 105ºC for 24 hrs. The dried sample was then cooled in a desiccator for 30 minutes and weighed.

The ash content was determined by the incineration of 2g dried sample in a muffle furnace at 55ºC for 2hrs. Crude lipid (CL) was Soxhlet extracted from 2g dried sample with n-hexane for 8hrs.The nitrogen (N) content was estimated by micro-Kjeldahl method and crude protein (CP) content calculated as N% x 6.25. Crude fibre (CF) content was determined by treating 2g dried sample with 1.25% (w/v) H_2SO_4 and 1.25% (w/v) NaOH. The available carbohydrate (CHO) was calculated by difference. Calorific value (CV) was determined using the following equation:

CV (kcal/100g) = (CHO x 4) + (CL x 9) + (CP x 4) (Hassan *et al*., 2008)

2.3. Mineral Analysis

Mineral analysis was carried out after sample digestion of 2g of the dried sample with 24cm^3 mixture of nitric acid/perchloric/sulphuric acids in the ratio 9:2:1 respectively. Ca, Mg, Fe, Mn, Cr, Cu and Zn were determined by atomic absorption spectrophotometry, Na and K by atomic emission spectrometry (AOAC, 1990), and P by the molybdenum blue colorimetric method (James, 1995).

2.4. Amino acids Analysis

Amino acids composition of the seed kernel was determined using the method reported by Magdi (2004). Duplicate samples were hydrolyzed by transferring 50mg of the sample into a 15ml ampoule, adding 5ml of 6M HCl, sealing the vial under vacuum, flushed with nitrogen, and digesting at 110ºC for 24hrs. The sulphur-containing amino acids were determined using perfomic acid. Amino acids analyses were performed by high performance liquid chromatography (Shimadzu, G-C-14A, Kyoto, Japan).

2.5. Anti-nutritional Analysis

The analytical methods reported by Umar *et al*. (2007) was adopted for determination of total oxalate, 1g of the sample, 75cm^3 of 15N H_2SO_4 was added. The solution was carefully stirred intermittently with a magnetic stirrer for 1hr and filtered using Whatman No1 filter paper. 25cm^3 of the filtrate was then collected and titrated against 0.1N $KMnO_4$ solution until a faint pink colour appeared that persisted for 30sec.

For determination of phytate, the method of Reddy and Love (1999) was employed. 4g of the sample were soaked in 100cm^3 of 2% HCl for 5hours and filtered. To 25cm^3 of the filtrate, 5cm^3 of 0.3% ammonium thiocyanate solution was added. The mixture was then titrated with iron (III) chloride solution until a brownish-yellow colour that persisted for 5minutes was obtained.

The tannin content was determined using Folin Denis reagent as reported by Abdel *et al*. (2007). In that method, a standard calibration curve was prepared and the Absorbance (A) against concentration of tannins at specific wave length was estimated as follows: Suitable aliquots of the tannin-containing extract (initially: 0.05, 0.2 and 0.5cm^3) were pipetted in test tubes, the volume was made up to 1.00cm^3 with distilled water, then 2.5cm^3 of sodium carbonate reagent were added. The tubes were shaken and the absorbance was recorded at 725nm after 40 min. The amount of tannin was calculated as tannic acid equivalent from the standard curve.
Saponin was determined using the method reported by Umar *et al*. (2007). 20cm^3 of 20% aqueous ethanol was added to 10g of the sample and agitated with a magnetic stirrer for 3hours at 55^{0}C. The solution was then filtered using Whatman No1 filter paper and the residue re-extracted with 200cm^3 20% aqueous ethanol. The extract was reduced to 40cm^3 under vacuum and 20cm^{3}diethyl ether were added in a separating funnel and shaken vigorously. The aqueous layer was recovered and the ether layer discarded. The p^H of the aqueous solution was adjusted to 4.5 by adding sodium hydroxide solution, and the solution shaken with 60cm^3 n-butanol. The combined butanol extracts were washed twice with 10cm^3 of 5% aqueous NaCl and evaporated to dryness in a fume cupboard to give crude saponin which was then weighed.

3. STATISTICAL ANALYSIS

The Data obtained were statistically analyzed using one way analysis of variance (ANOVA) with SPSS version 10.0 statistical package and the results were expressed as mean ± standard deviation of three replicates.

4. RESULTS AND DISCUSSION

Proximate composition: The result of proximate composition is presented in Table 1. The moisture content (12.55%W/W) was higher than the value reported by Umar *et al*. (2013) in the wild melon (*Citrullus acirrhosus*) seeds (3.73%W/W) also higher than 10.57%WW recorded in the seed of gingerbread plum (*Neocarya macrophylla*) seeds (Tidjani *et al*., 2010). The variation could be due to genetic variation as well as the climatic conditions in which the plants were grown. Higher moisture content is associated with a rise in microbial activities during storage (Hassan and Umar, 2004).

The ash content of the shoot was 5.52% dry weight (DW), which is an indication that it contains nutritionally important mineral elements. The value obtained is relatively higher than 4.43%DW reported in the seeds of gingerbread plum (*Neocarya macrophylla*) seeds (Tidjani *et al*., 2010).

The gingerbread plum (*Neocarya macrophylla*) seeds contain high level of crude lipid (50.50%DW) which is comparable to 50.56%DW recorded in the seeds of wild melon (*Citrullus acirrhosus*) reported by Umar *et al*. (2013) but higher than 47.28%DW reported in the seeds of gingerbread plum (*Neocarya macrophylla*) reported by Tidjani *et al*. (2010). Due to the high lipid content of the fruit, it could be use as a potential source of oil.

The seeds contain 7.67%DW crude fiber which is lower than 8.70%DW reported in the seeds of *Neocarya macrophylla* obtained from Niger republic (Tidjani *et al*., 2010). The value obtained is higher compared to the 2.17%DW reported in the wild melon (*Citrullus acirrhosus*) reported by Umar *et al*. (2013). The higher fiber obtained support bowel regularity, maintain normal cholesterol levels and blood sugar levels, reduce constipation and also prevention of heart diseases (Wasagu *et al*., 2013).

The seeds crude protein content is 23.24%DW, which is higher than 20.37%DW in the seeds of *Neocarya macrophylla* reported by Tidjani *et al.* (2010). According to Watt and Merrill (1963), plant foods that provide more than 12% of its calorific value from protein are considered good source of protein and this indicates that the seed under investigation is a potential source of protein.

The main function of carbohydrate is for energy supply. The seeds of *Neocarya macrophylla* had 6.04%DW carbohydrates which is lower than 8.64%DW and 19.20%DW reported in the seeds of *Neocarya macrophylla* and seeds of African locust bean reported by Tidjani *et al*. (2010) and Osagie *et al*. (1986) respectively. The result shows that the seeds of *Neocarya macrophylla* could supplement the energy requirements for some of our daily activities.

The calorific value of the *Borassus aethiopum* shoots is 571.62kcal/100g. The recorded value is lower than 601.70kcal/100g reported in the seeds of wild melon (*Citrullus acirrhosus*) (Umar *et al.*, 2013). The energy value is within the range of recommended daily intake of 300kcal of energy per 65kg body weight adult human (Muller, 1988). The seeds therefore if consumed in good quantity could be a good source of energy.

Table 1: Proximate Composition of *Neocarya macrophylla* seed kernel (g/100gDW)

Parameter	Concentration
Moisture**	12.55 ± 1.11
Ash	5.52 ± 1.45
Crude protein	23.24 ± 2.45
Crude fiber	7.67 ± 0.67
Crude lipid	50.50 ± 2.11
Available Carbohydrate	6.04 ± 1.22
Energy value (kcal/100g)	571.62 ± 2.66

The values are mean ± standard deviation of triplicate result

Minerals Composition: The minerals content of *Neocarya macrophylla* seeds is shown in Table 2. Sodium level in the seeds of *Neocarya macrophylla* is 78.76 ± 1.98mg/100gDW. The value is higher than 3.80mg/100g for African locust bean (Hassan and Umar, 2004) and also higher than 23.15mg/100gDW for wild melon seeds (Umar *et al*., 2013). The daily dietary allowance of sodium is 200-500mg (RDA, 1989). This indicates that the seed has an appreciable amount of sodium.

The potassium level in the seeds (489.12 ± 2.88mg/100gDW) was lower than 2962mg/100gDW for wild melon seeds (Umar *et al*., 2013) but higher compared to 366mg/100g/100DW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). Potassium is an important element which helps in maintenance of acid-base balance in the body and normal functioning of nervous system (Oshodi *et al*., 1999).

The concentration of calcium in the seeds (312.55 ± 3.66mg/100gDW) is higher than 38.45mg/100gDW recorded for wild melon seeds (Umar *et al*., 2013) and lower than 403.08mg/100gDW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). The recommended daily allowance (RDA, 1989) for calcium is 1000mg for adult. Hence the seed could contribute 31.25% of the dietary requirement.

Magesium content of *Neocarya macrophylla* seeds (503.08 ± 1.70mg/100g) was higher than 206.14mg/100gDW for *Sclerocarya birrea* seeds, and higher than 210.36mg/100g for *Hasta lapasta* seeds (Muhammad *et al*., 2011; Hassan *et al*., 2009). However the value is lower than 1315.50mg/100gDW for wild melon seeds (Umar *et al*., 2013). Magnesium activates enzymatic systems responsible for calcium metabolism in bones and in the nerves electrical potential (Ishida *et al*., 2000). The recommended dietary allowance of magnesium for adult was 350mg (RDA, 1989). Therefore, 100g of the seed could supply the body with 14.37% of the body daily magnesium requirement.

The phosphorus content of *Neocarya macrophylla* seeds (19.17 ± 2.77mg/100gDW) is within the range of (12.2 – 79.9mg/100g) reported for some conventional seeds and nuts (Almustafa *et al*., 1995).

Manganese concentration in the seeds (1.21 ± 0.99mg/100gDW) is lower than 4.71mg/100gDW and 6.05mg/100gDW for *Sclerocarya birrea* seeds and wild melon seeds reported by Muhammad *et al*. (2011) and Umar *et al*. (2013) respectively. The recommended dietary allowance of manganese was 5mg (RDA, 1989). Therefore, the seed could contribute 24% of the required dietary for manganese. Manganese helps in supporting the immune system, regulating the sugar level in blood and contributes in the energy production during cell division. More so, deficiency in manganese could result to birth defects in pregnant women (Bello *et al*., 2008).

The seed iron contents (20.55 ± 3.23mg/100gDW) is lower than 49.40mg/100gDW for wild melon seeds (Umar *et al*., 2013) and higher than 4.76mg/100gDW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). The value recorded indicates that, when compared with 18mg set as recommended daily intakes for iron (FDA, 2001), consumption of the seed kernel could cover the daily intakes requirement. Iron is utilized in the body for transportation of oxygen to the tissue and melanin formation (House, 1999). It is also an important element in the diet of pregnant women, nursing mothers, infant, convulsive patients and elderly to prevent anaemia and other related diseases, but prolong consumption can result in liver failure (House, 1999).

The concentration of copper in the seed (0.77 ± 0.12mg/100gDW) was lower than 5.10mg/100gDW and 4.74mg/100g for wild melon seeds and *Sclerocarya birrea* seeds (Umar *et al*., 2013; Muhammad *et al*., 2010). The recommended dietary allowance for copper was 2mg (RDA, 1989). Thus, consumption of the seed could supplement the body with 38.5% of the dietary requirement.

The amount of zinc in the seed (1.24 ± 0.77mg/100gDW) is lower than 22.05mg/100gDW recorded for wild melon seeds (Umar *et al*., 2013) also lower compared to

3.29mg/100gDW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). The recommended dietary allowance of zinc was set as 12mg (NRC, 1981), which indicate that, the seed could contributes 10.3% of the dietary requirement. Zinc is known to play an important role in gene expression, regulation of cellular growth and participates as a co-factor of enzymes responsible for carbohydrate, proteins and nucleic acid metabolism (Camara and Amaro, 2003).

Table 2: Minerals Composition of *Neocarya macrophylla* seed kernel (mg/100gDW)

Mineral Element	Concentration
Na	78.76 ± 1.98
K	489.12 ± 2.88
Ca	312.55 ± 3.66
Mg	503.08 ± 1.70
P	19.17 ± 2.77
Mn	1.21 ± 0.99
Fe	20.55 ± 3.23
Cu	0.77 ± 0.12
Zn	1.24 ± 0.77

The values are mean ± standard deviation of triplicate result

Amino acids Profile: The amino acids profile of *Neocarya macrophylla* seed is presented in Table 3. The amino acids content of the seed can be compared with other results obtained from other seeds. The glutamic acid (20.50%) and arginine (10.45%) have the highest proportion compared to the other amino acids in the sample. Similar trend was observed wild melon seeds (Umar *et al*., 2013) and *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). The result indicates that non essential amino acids are high in concentration and accounted for (66.48%) of the total amino acids detected, while the essential amino acids constitutes 31.44% of the total amino acids analyzed. Among the essential amino acids phenylalanine (6.20%), leucine (5.99%), and valine (4.36%) are the predominance acids in the seeds.

Table 3: Amino acids Profile of *Neocarya macrophylla* seed kernel (g/100g protein)

Amino acid	Concentration
Leucine*	5.99
Threonine*	3.00
Valine*	4.36
Isoleucine*	2.86
Methionine*	2.14
Cystein*	2.10
Lysine*	2.79
Phenylalanine*	6.20
Tyrosine*	2.00
Glysine**	5.96
Alanine**	3.22
Serine**	6.97
Aspartic acid**	9.58
Glutamic acid**	20.50
Proline**	6.89
Argenine**	10.45
Histidine**	2.91

The values are mean of duplicate result, ** Non-essential amino acids, * Essential amino acids

To evaluate the nutritional quality of *Neocarya macrophylla* seeds, the percentage of the essential amino acids were compared with those of reference standard amino acid profile established for both adults and preschool children by WHO/FAO/UNU (1985) and the result is presented in Table 4. The essential amino acids (leucine, lysine and threonine) are below the standard requirement for preschool children and therefore limited, while for adults all the essential amino acids are above the reference standard value which indicates that the seeds of *Neocarya macrophylla* if properly utilized could supply the teaming population with the required dietary protein for both preschool children and adults.

Table 4: Results for Amino acids score of *Neocarya macrophylla* Seed kernel

Essential Amino acids	Amino acids Concentration (g/100g protein)	WHO Ideal Value A B	(% Aminoacids/Ideal) x 100 Children Adult
Isoleucine	2.86	2.8	102 220
Leucine	5.99	6.6 1.9	90 315
Lysine	2.79	5.8 1.6	48 174
Threonine	3.00	3.4 0.9	88 333
Valine	4.36	3.5 1.3	124 335
Cystine + Methionine	4.24	2.5 1.7	169 249
Phenylalanine + Tyrosine	8.20	6.3 1.9	130 431
SCORE			**4/7** **7/7**

Anti-nutritional Composition: The result of anti-nutritional composition of *Neocarya macrophylla* seed is presented in Table 5. From the result, phytate is the most abundant anti-nutritional factor in the seeds (390.42 ± 11.00mg/100g DW) which is higher than 55.0mg/100g DW reported in the seed of *Artocarpus heterophyllus* (Bello *et al*., 2008) and lower than 423.09 ± 1.89mg/100DW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). Phytate is a strong chelating agent that binds dietary essential minerals such as zinc, calcium and iron to form complexes thereby decreasing the bioavailability of these minerals (Fergusin *et al*., 1993).

The total oxalate content of the seed is 46. 91 ± 1.80mg/100gDW. The recorded value is higher compared to 23.0mg/100gDW for *Artocarpus heterophyllus* seeds (Bello *et al*., 2008), but lower compared to 67.56 ± 0.28mg/100gDW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). Presence of oxalate in food causes irritation in the mouth and interfere with absorption of divalent minerals particularly calcium by forming insoluble salt with them

(Hassan and Umar, 2004). Consumption of oxalate may results in kidney disease (Onibon *et al*., 2007).

Tannins content of the seed is 112.78 ± 2.80mg/100g DW. The value obtained is relatively higher compared to 108mg/100gDW for *Artocarpus heterophyllus* seeds (Bello *et al*., 2008) but lower compared to 3136.39 ± 3.85mg/100gDW for *Sclerocarya birrea* seeds (Muhammad *et al*., 2011). Tannins in the biological system have the ability to chelate protein making it impossible or difficult to digest (Alerto, 1993).

The saponin content of *Neocarya macrophylla* is 3.35 ± 1.34g/100gDW. The recorded value is lower than 10.510g/100gDW and 8.26 ± 0.13g/100gDW for *Adansonia digitata* seeds and *Sclerocarya birrea* seeds respectively (Umaru *et al*., 2007; Muhammad *et al*., 2011). High saponin content has been associated with gastro-enterities manifested by diarrhea and dysentery (Awe and Sodipo, 2001). However, it was reported that saponin reduces body cholesterol by preventing its reab-sorption and suppresses rumen protozoan cell membrane thereby causing it to lyse (Umaru *et al*., 2007).

Table 5: Anti-nutritional Composition of *Neocarya macrophylla* seed kernel (mg/100gDW)

Parameter	Concentration
Total oxalate	46. 91 ± 1.80
Tannin	112.78 ± 2.80
Phytate	390.42 ± 11.00
Saponin*	3.35 ± 1.34

The values are mean ± standard deviation of triplicate result, * g/100gDW

To predict the bioavailability of some divalent elements specifically calcium, magnesium, zinc and iron, anti nutrients to nutrients molar ratios were calculated and the results presented in Table 6. From the results, it was observed that, [oxalate] / [Ca], [oxalate] / [Ca + Mg] ratio are below the critical level known to impair calcium bioavailability (Umar, 2005). [phytate] / [Ca] ratio was (7.59×10^{-2}). When compared to the critical level (0.2), the [phytate] / [Ca] is low compared to the critical value known to cause calcium deficiency by the phytate. The [phytate] / [Zinc] ratio (31.16) is higher than the critical value (10) known to impair zinc bioavailability and thus indicate poor zinc bioavailability due to phytate. Mitchikpe *et al*. (2008) reported that, for iron bioavailability, [phytate] / [Fe] should not exceed 0.4; the result obtained was above the critical value which called for consumption of iron enhancers such as vitamin C and meat together with the kernel.

Table 6: Antinutrient to Nutrients Molar Ratio

Antinutrient to Nutrients	Molar Ratio	Critical level
[Oxalate]/[Ca]	6.67×10^{-2}	2.5
[Oxalate]/[Ca + Mg]	1.81×10^{-3}	2.5
[Phytate]/[Ca]	7.59×10^{-2}	0.2
[Phytate]/[Fe]	1.60	0.4
[Phytate]/[Zn]	31.16	10

5. CONCLUSION

The analytical results revealed that gingerbread plum (*Neocarya macrophylla)* seed is potentially a good source of oil, calorific value and some essential mineral elements of nutritional benefit. The seed also contain appreciable amount of protein with amino acids that meet the standard of the FAO/WHO/UNO. Therefore, the seed if possessed the potentials to be as source of protein. The anti-nutrient to nutrients molar ratio indicates that the seed is relatively safe for consumption subject to toxicological studies.

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REFERENCES

Abdel, M.S, Fatima, MI, Elamin, AE. (2007). Quantitative determination of tannin content in some sorghum cultivars and evaluation of its antimicrobial activity. Research Journal of Microbiology, **2:** 284 - 288.

Alan, W. (1996). Soil and the environment: An introduction, Cambridge University press.

Alerto, V. A. (1993). Allelo chemical in plant food and feeding stuffs I. Nutritional, Biochemical and Physiopatholgical Aspects in Animal Production. *Veterinary Human Toxicology* 35: 57-67.

Ali, A and Deokule, S. S. (2009). Studies on Nutritional Values of Some Wild Edible Plants from Iran and India. *Pakistan Journal of Nutrition* **8(1):** 26-31.

Almustafa, D.A., L. S. Bilbis, J.M. Rades, M.K. Abubakar. (1995). Chemical Composition of some Oil seeds grown in Northern Nigeria. *Journal of Biochemistry and Molecular Biology*, **10:** 39 – 43.

Amza, T., Amadou, I., Kamara, M.T., Zhu, K.X., Zhou, H.M. (2011). Nurtitional and functional characteristics of gingerbread plum (*Neocarya macrophylla*): an underutilized oilseed. *Advance Journal of Food Science and Technology*, **62(3):** 290 – 298.

Awe, IS., Sadipo, OA. (2001). Purification of Saponins of root of *Blighia sapida*. *Nigerian Journal of Biochemistry and Molecular Biology*, **16(3):** 201 – 204.

AOAC. (1990). *Official methods of analysis*, 14th edition, Association of Official Analytical Chemists, Washington DC.

Audu,OT, Oyewale, AO, Amupitan, JO. (2005). The biological activities of secondary metabolites of *Parinari macrophylla* Sabine. *Chem Class Journal*, **2:** 19 -21.

Bello, M.O., Falade, O.S., Adewusi, S.R.A., Olawore, N.O. (2008). Studies on the Chemical Compositions and Anti-nutrients of some lesser known Nigerian Fruits. *African Journal of Biotechnology*, **7:** 3972 – 3979.

Camara, F and Amaro, C.A. (2003). Nutritional Aspects of Zinc Availability. *International Journal of Food Sciences and Nutrition* **54:**143 -152.

Cook, JA., Vanderjagt, DJ., Pastuszyn, A., Mounkaila, G., Glew, RS., M. Millson, Glew, RH. (2000). Nutritional and Chemical Composition of 13 Wild plant foods of Niger. *Journal of Food Composition and Analysis*, **13(1):** 83 – 92.

FAO/WHO/UNU. (1985). Energy and Protein requirements. Reports of joint FAO/WHO/UNU Expert Consultation. Technical Report SeriesNo. 724. Geneva.

Fergusin, E. L., Gibson, R.A., Opara-obisaw, O., Stephen, A.M and Thomson, L. U. (1993). The Zinc, calcium, copper,magnesium, non-starchpolysaccharide and phytate content of seventy eight locally grown and prepared African foods. *Journal of Food Analysis*. **6:** 337-342. Hassan, L.G. and Umar, K.J. (2004). Proximate and mineral composition of seeds and pulp of African locust bean (*Parkia biglobosa L.*). *Nigerian Journal of Basic and Applied Sciences.* **13:** 15-27.

FDA. (2001). Food and Drug Administration. US Government Laws, Regulations, Decisions and Guidelines Catalog. Code of Federal Regulations. http://Frwebgate.access.gpo.gov/cgi-bin/ Retrieved on 22nd September, 2009.

Hassan, L.G. and Umar, K.J. (2004). Proximate and mineral composition of seeds and pulp of African locust bean (*Parkia biglobosa L.*). *Nigerian Journal of Basic and Applied Sciences.* **13:** 15-27.

Hassan, L.G., Muhammad, M.U., Umar, K.J. and Sokoto, A.M. (2008). Comparative Study on the Proximate and Mineral Contents of the Seeds and Pulp of Sugar Apple (*Annona squamosa*). *Nigerian Journal of Basic and Applied Sciences* **16(2):** 174-177.

Hassan, L. G., Usman, B. B., Kamba, A. S and Hassan, S. W. (2009). Nutritional Composition of Vegetable Spaghetti (*Hasta la pasta*) fruits. *Nigeria Food Journa*l. **27(2):** 41-49.
House, W.A. (1999). Trace Element Bioavailability as exemplified by Iron and Zinc. *Field Crops Research* **60:** 115 – 141.

Ishida, H., Suzuno, H., Sugiyama, N., Innami, S., Todokoro, T. And Maekawa, A. (2000). Nutritional Evaluation of Chemical Components of Leaves Stalks and Stems of Sweat potatoes (Ipomea batata poir). *Food Chemistry* **68:** 359-367.
James, C. A. (1995). "*Analytical Chemistry of Food*." Chapman and Hill, London.

Magdi, A. Usman. (2004). Chemical and Nutrient Analysis of Baobab (*Adansonia digitata*) Fruit and Seed Protein Solubility. *Plant Food for Human Nutrition* **52:** 29-33.

Mitchikpe, E. C. S., Dossa, R. A. M., Ategbo, E. A. D., Vanraaij, J. M. A. Hulshof, P. J. M and Kok, F. J. (2008). *Journal of Food Composition and Analysis.* **21:** 17-25

Motlhanka, A., Daniel, O., Ebineng, T. (2012). Analysis of Nutrients, Total polyphenols and Antioxidant activity of Ficus sansibarica Fruits from Eastern Bostwana. *Journal of Drug delivery and Therapeutics*, **2(6):** 1 – 5.

Muhammad, S., Hassan, L.G., Dangoggo, S.M., Hassan, S.W., Umar, K.J., Aliyu, R.U. (2011). Nutritional and Antinutritional Composition of *Slerocarya birrea* Seed kernel. *Studia Universities " Vasile Goldis " Seria Stiintele Vietii*, **21(4):** 693 – 699.

Muller, H.G. (1988). *An Introduction to Tropical Food Science*. Cambridge University Press, Cambridge, 59 – 118.

Nordeide, M.B., Hatloy, A., Folling, M., Lied, E. and Oshaug, A. (1996). Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in southern Mali. *International Journal of Food Sciences and Nutrition.* **47:** 455-468.

Onibon, V.O., Abulude, F.O and Lawal, L.O. (2007). Nutritional and Anti-Nutritional Composition of Some Nigerian Fruits. *Journal of Food Technology* **5(2):** 120-122.

Osagie, A.U., Okoye, W.L., Olawayeso, B.O., Awodu, A.O. (1986). Chemical quality parameters and fatty acids composition of oils of some under exploited tropical seeds. *Nigerian Journal of Applied Sciences*, **4:** 151 – 162.

Oshodi, A.A., Ipinmoroti, K.O. and Fagbemy, T.N. (1999). Chemical Composition, Amino acid Analysis and Functional Properties of Bread nut (*Artocarpus altillies*) Flour. *Nahrung/Food* **43:** 402-405

Reddy, MB., Love, M. (1999). The Impact of Food processing on the Nutritional quality of Vitamins and Minerals. *Advance Experiments on Medicinal Biology*, **459:** 99 – 106.

Spiller, G.A. (2001). Dietary fiber in prevention of and treatment of disease. In: Handbook of dietary fiber in human nutrition, CRC Press LLC, Washington, 363 – 431.

RDA. (1989). Recommended Dietary Allowance. 10th Edition, National Academic Press, Washington, DC., USA.
Tidjani Amza, Issoufou Amadou, Mohamed, T. Kamara, Kexue Zhu, Huimin Zhou. (2010). Chemical and Nutrient Analysis of Gingerbread plum (Neocarya macrophylla) Seeds. *Advance Journal of Food Science and Technology*, **2(4):** 191 – 195.

Umar, K.J. (2005). Proximate Analysis of Seeds and Pulp of African locust bean (*Parkia biglobosa*). M.Sc. Dissertation, School of Postgraduate Studies, Usmanu Danfodiyo University, Sokoto, Nigeria.

Umaru, H.A., Adamu, R., Dahiru, D. and Nadro. M.S. (2007). Level of Antinutritional Factors in Some Wild Edible Fruits of Northern Nigeria. *African Journal of Biotechnology* **6(6):** 1935 – 1938.

Umar, K.J., L.G. Hassan, H. Usman, R.S.U. Wasagu. (2013). Nutritional Composition of the Seeds of Wild Melon (*Citrullus ecirrhosus*). *Parkistan Journal of Biological Sciences*, **16:** 536 -540.

Wasagu, R.S.U., Lawal, M., Shehu, S., Alfa, H.H., Muhammad, C. (2013). Nutritive values and Antioxidant properties of *Pistiastratiotes* (Water lettuce). *Nigerian Journal Basic and Applied Sciences,* **21(4):** 253.

Watt, BK., Merrill, AL. (1963). Composition of foods. Agricultural Handbook No. 8. Wshington, DC: U. S. Department of Agriculture.