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NUTRITIONAL AND ANTINUTRITIONAL COMPOSITION OF SCLEROCARYA BIRREA SEED KERNEL

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ABSTRACT
The seed kernel of *Sclerocarya birrea* was evaluated for its nutritional and antinutritional composition. The results show that the moisture, ash, crude protein, crude lipid, crude fibre, available carbohydrate and energy value were 10.47% weight wet, 4.67%, 30.97%, 58.88%, 2.51%, 2.97% and 665.67kcal/100g dry weight respectively. The result of minerals analysis showed that the kernel is a good source of both macro and micro elements with calcium as predominant. The kernel has a good source of some essential amino acids especially leucine and sulphur containing amino acids. The concentrations of hydrocyanic acid, nitrate, oxalate and phytate were lower than the reference toxic standard level. This new data suggests that the seed kernel of the fruit has adequate dietary nutrients and the antinutrients composition is within tolerable level.
Keywords: Nutritional, antinutritional, *Sclerocarya birrea,* kernel.

INTRODUCTION

Developing nations are devastated by hunger and diseases even though the nations have abundant biota and other natural resources from which if properly used could solve the problems. Life style in Africa is changing due to urbanization, which lead to and causes under utilization of wild food particularly in urban areas (Vainio-Matila, 2000). However, some diseases such as diabetes, obesity, cancer and cardiovascular diseases are manifesting in developing countries than ever before; and are due to inadequate consumption of fruits and vegetables. If this trend continues, World Health Organization (WHO) projected that, the percentage of people living with diabetes alone in developing countries will rise by 170% by the year 2025 (Ganry,2008). The problems are due to nutritional transition—ingestion of refined food in substitute to locally available food material particularly wild fruits and vegetables, which are considered "food for the poor".

Macro and micronutrients in plant food are useful as nutrients supplements and are recommended to be better than processed foods. The rise in nutritional importance of fruit has been stimulated by a range of degenerative diseases prevalent in many part of the world (Wenkam, 1990). However, apart from the nutritional advantages of the fruit and seed kernel, they may also contain anti-nutritional factors such as nitrates, phytates, tannins and oxalates. Phytic acid in food has the ability to chelate divalent elements like calcium, while tannins precipitates dietary proteins and digestive enzymes to form complexes not readily digestible (Alerto, 1993). Oxalic acid removes calcium from the blood in the form calcium oxalates and may cause kidney damage.

In the Hausa – speaking regions of the Republic of Nigeria, majority of people rely on millet as the staple food stuff of their diet. However, during times when crops yields are low the population must seek other alternative sources such as wild plant to supplement the conventional sources. Nutritionally, literature indicated that, wild plants which are considered "food for the poor" are rich sources of minerals, vitamins, fibre, amino acids, poly unsaturated fatty acids and antioxidants (Umar, 2008). Therefore, if screened and integrated into our horticulture system, they would boost food production and will be an agent of hunger and disease eradication. Among the commonest wild plants known in Northern part of Nigeria is *Sclerocarya birrea* commonly known as "*Nunu*" or "*Loda*" or "*Daniya*" among the Hausa language (Glew *et al*., 2004). Details botanical profiled of the tree has been reported (Kokwaro and Gillett, 1980; Kokwaro, 1986; FAO, 1988; Palgrave, 1988). The mature fruits (3-3.5cm in diameter) of *Sclerocarya birrea* are green but change to yellow when riped. The fruit contain a white clinging flesh and a large stone from which the kernel can be obtained. Antinutritional composition and toxicological studies of *Sclerocarya birrea* fruit juice have been reported (Hassan and Umar, 2004; Hassan *et al*., 2011). Plate 1 shows the ripe fruits of *Sclerocarya birrea.*

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Plate 1: Ripe fruits of *Sclerocarya birrea.*

Nutritional information of the seed kernel of the plant in North – Western Nigeria is scanty. Hence, due to nutritional benefits of the fruit juice of *Sclerocarya birrea*, literature knowledge about the nutritional and antinutritional factors of the seed kernel should also be provided. This study was aimed to determine the nutritional and antinutritional composition of *Sclerocarya birrea* seed kernel in order to establish its potential as a source of nutrients supplement.

MATERIALS AND METHODS

Sampling and sample treatment

One kilogramme (1 kg) of matured and ripe *Sclerocarya birrea* fruits were collected in June, 2010 from More**,** Kware local government area of Sokoto State, Nigeria. Five (5) trees were randomly selected and the fruits were collected from different branches of the trees, as described by Hassan and Umar, 2004). Representative sample was taken using alternate shovel method (Alan, 1996). The juice, peels and seeds were separated by squeezing ripe fruits. The seeds were air dried and the kernel was removed manually using hammer, pulverized to fine powder using pestle and mortar, sieved to pass through 80-meish sieve and stored in air tight paper bags inside a desiccator. The dried powder was used for the analysis other than moisture content in which fresh sample was used.

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 105^{o}C 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 55^{o}C 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) x (CL x 9) x (CP x 4) (Hassan *et al*., 2008).

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, Co, Mn, Cr, Ni, 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).

Amino acids analysis

Amino acids composition of the seed kernel was determined using the method reported by Usman (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 110^{o}C 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).

Antinutritional analysis

The method of Ola and Oboh (2000) was adopted for determination of phytate. Hydrocyanic acid was determined by the AOAC (1990) method. Oxalate and nitrate were determined by the methods of Krishna and Ranjhan (1980). For determination of tannins the method of van-Burden and Robinson (1981) was employed.

Statistical Analysis

Data generated in triplicates were expressed as mean ± standard deviation using SPSS version 10 statistical packages.

RESULTS AND DISCUSSION

Proximate composition: The result of proximate composition is presented in Table 1. The moisture content was generally low in the kernel (10.47% wet weight). The value recorded was higher than 6.13% WW and 7.50% WW recorded in *S. birrea* seed kernel and *Lophira lanceelata* seed kernel (Ighodalo and Catherine, 1991). Similarly, the moisture content in the kernel was high compared to 5.5% WW in the seed kernel of *Zizyphus sonorensis* (Marcelino *et al.,* 2005). Higher moisture content is associated with a rise in microbial activities

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during storage (Hassan and Umar, 2004), therefore, the seed kernel should be properly dried before storing.

The ash content of the kernel was 4.67% dry weight (DW), which is an indication that, the kernel contains nutritionally important mineral elements. The value in the kernel was higher than 2.0% DW in the seed kernel of *Zizyphus sonorensis* (Marcelino *et al.,* 2005), but lower than 6.5% DW in the kernel of baobab seed reported by (Chadare *et al.*, 2009). Similarly, the value was relatively higher than 3.75% DW in the kernel of *S. birrea* fruits reported by Ighodalo and Catherine (1991).

The kernel has a crude protein content of 30.97% DW. The value was in agreement with (30.80% DW) in the kernel of *S. birrea* seed but higher than 27.0% DW observed in the kernel of *Lophira lanceelata* seed (Ighodalo and Catherine, 1991), the value was relatively lower than 32.7%DW recorded in the kernel of baobab seed (Chadare *et al.*, 2009). When compared with 19g set as recommended daily intakes for children 4-8 years (Chadare *et al.*, 2009), the kernel can supply 163% of the daily intake.

The crude lipid content of the seed kernel was 58.88% DW. The value observed in the kernel is within the range of 53.50 – 60%DW in the kernel of *S. birrea* seed but higher than 40.0% DW recorded in the kernel of *Lophira lanceelata* seed (Ighodalo and Catherine, 1991). The value recorded in the kernel was higher than 27.80% DW recorded in the kernel of baobab seed reported by Chadare *et al*. (2009), also higher than 44.0% DW observed in the seed of Sugar apple (*Annona squamosa*) reported by Hassan *et al*. (2008). Lipids are the principal sources of energy but should not exceed the daily recommended dose of not more than 30 Calories so as to avoid obesity (Hassan *et al.*, 2008).

The crude fibre content of the kernel was 2.51% DW. The observed value was relatively higher than 2.40% DW in the kernel of *S. birrea* seed (Engelter, and Wehmeyer, 1990). The value was low compared to 21.20% DW in the kernel of baobab seed (Chadare *et al.*, 2009) also lower than 36.33% DW in the seed of Sugar apple (*Annona squamosa*) reported by Hassan *et al*. (2008). Hassan and Umar (2004) have reported that consumption of vegetable fibre can reduce serum cholesterol level, risk of coronary heart disease, hypertension, it also enhance glucose tolerance and increase insulin sensitivity. Thus, the fruit could be a good source of dietary fibre and could have potential of providing some human body requirements.

The available carbohydrate content of the kernel was 2.97% DW. The value observed in the kernel was lower than 17.32% DW and 24.05% DW and *Lophira lonceelata* respectively Ighodalo and Catherine, 1991), but high compared to 34.52% DW in baobab seed (Chadare *et al.*, 2009). The main function of carbohydrate is for energy supply, there fore; the kernel could be use to supplement carbohydrate especially to rural populace.

The calorific value of the kernel was 665.67kcal/100g DW. The value recorded was low compared to 1965kcal/100g DW observed in the seed kernel of Baobab (Chadare *et al.*, 2009), similarly, the value was lower than 1065kcal/100g DW recorded in the seed kernel of *Zizyphus sonorensis* (Marcelino *et al.,* 2005). The observed values indicate that, the kernel contributes 9.95% of 6691kJ set as recommended daily intakes (Chadare *et al.*, 2009).

Table 1: Proximate composition of the seed kernel of *Sclerocarya birrea* **fruits (%DW)**

	Concentration
Moisture*	10.47 ± 0.33
Ash	4.67 ± 0.15
Crude protein	30.97 ± 1.17
Crude lipid	58.88 ± 0.59
Crude fibre	2.51 ± 1.50
Available carbohydrate	2.97 ± 1.90
Calorific value (Kcal/100g)	665.67 ± 2.0

The data are mean value ± standard deviation of three replicates. * Value expressed as % weight wet.

Minerals composition: The minerals profile of the kernel is reported per 100g and the result presented in Table 2. Calcium was the most abundant (403.08mg) element, followed by potassium (366mg) and then magnesium (206.14mg). The calcium content is high when compared with 154mg/100g DW in the seed of *S. birrea* (Glew *et al.*,2004), but lower than 650mg/100g DW in the seed of Sugar apple (Hassan *et al.*, 2008). The contents of sodium, iron and copper were 27.49mg, 4.76mg and 4.74mg and were higher than respective values of 4.27mg, 2.77mg and 2.48mg reported in *S. birrea* (Glew *et al.*, 2004). The kernel also contains a reasonable amount of manganese (4.71mg), nickel (2.44mg), zinc (3.29mg) and chromium (1.98mg). This is an indication that, the kernel could supplement the body with both macro and microelements.

Table 2: Minerals composition of the seed kernel of *Sclerocarya birrea* fruits (mg/100g DW)

Mineral element	Concentration
Na	4.76 ± 0.47
K	366.0 ± 2.00
P	2.87 ± 2.10
Ca	403.08 ± 1.97
Mg	206.14 ± 3.14
Fe	27.49 ± 0.11
Co	0.38 ± 0.14
Ni	2.44 ± 0.36
Mn	4.71 ± 0.38
Cu	4.74 ± 0.23
Zn	3.29 ± 0.12
Cd	0.03 ± 0.02
Pd	0.03 ± 0.01
Cr	1.98 ± 0.97

The data are mean value ± standard deviation of three replicates

Amino acids profile: The amino acids composition of the seed kernel is presented in Table 3. The results indicated that, the essential amino acids content was 30.93% while the non-essential amino acids content was 69.07%. Leucine was the predominant essential amino acids accounting for 7.37 ± 0.61%. On the non-essential amino acids, glutamic acid was the predominant (28.09 ± 0.16%) and this is in agreement with that of the seeds of *Hasta la pasta* fruits (Hassan *et al.,* 2009). Similarly, the recorded value is comparable with that recorded in the kernel of *S. birrea* seed reported by Glew *et al.* (2004).

To evaluate the nutritional quality of the kernel in terms of amino acids profile. The percentage essential amino acids in the kernel were compared with the WHO ideal protein (Table 4). From the results, it is clear that, the kernel can supply the required isoleucine, leucine, sulphur containing amino acids (methionine + cystine), threonine and valine, but is deficient of lysine and (phenylalanine + tyrosine. This is an indication that, the seed kernel if properly utilize can supply the teaming population with dietary protein.

Table 3: Amino acids composition of the seed Kernel of *Sclerocarya birrea* fruits (g/100g protein)

Amino acid	Concentration
Lysine (Lys) *	5.20 ± 0.12
Histidine (His)	2.61 ± 0.81
Arginine (Arg)	14.99 ± 2.11
Aspartic acid (Asp)	13.35 ± 0.50
Threonine (Thr) *	4.66 ± 0.38
Serine (Ser)	4.26 ± 0.36
Glutamic acid (Glu)	28.09 ± 0.16
Proline (Pro)	4.63 ± 0.14
Glycine (Gly)	3.54 ± 1.20
Alanine (Ala)	6.21 ± 1.23
Cystine (Cys)*	2.39 ± 1.40
Valine (Val) *	3.95 ± 1.90
Methionine (Met) *	1.65 ± 0.45
Isoleucine (Ile) *	3.83 ± 0.11
Leucine (Leu) *	7.37± 0.61
Tyrosine (Tyr)*	2.63 ± 0.24
Phenylalanine (Phe) *	3.11 ± 0.44

* Essential Amino acids. The data are mean ± Standard deviation of two replicates.

Table 4: Essential amino acids composition compared to the WHO ideal protein

Amino acid	% of total amino acid	% amino acid/ideal x 100	WHO (%) ideal protein
Isoleucine	3.8	137	2.8
Leucine	7.4	112	6.6
Lysine	5.2	70	5.8
Methionine + Cystine	4.0	162	2.5
Phenylalanine + Tyrosine	5.7	91	6.3
Threonine	4.7	137	3.4
Valine	3.9	113	3.5

Antinutritional factors: The result of antinutritional factors was presented in Table 4. The kernel has high phytate content of 423.09mg/100g DW. The value observed was higher than 2.98mg/100g DW in the seed of *Hasta la pasta* (Hassan *et al.*, 2009), 73.0mg/100g DW in the seed of baobab (Chadare *et al.*, 2009), 320mg/100g DW reported in the seed of *Zizyphus sonsrensis* (Marcelino *et al.*, 2005). Phytate chelates with mineral elements and protein in monogastic animals and render them not bioavailable (Hassan *et al.*, 2011).

The total oxalate content was 67.56mg/100g DW. The value observed was high compared to 9.45mg/100g DW recorded in the seed of *Hasta la pasta* (Hassan *et al.*, 2009). 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).

The amount of tannin was 3136.39mg/100g DW. The value observed was high compared to 320mg/100g DW in the seed of *Zizyphus sonorensis* (Marcelino *et al.,* 2005) and 39mg/100g DW in the seed of baobab (Chadare *et al.*, 2009). The astringent flavour of the kernel could be associated with the high tannin content. Tannin in the biological system has the ability to chelate protein making it impossible or difficult to digest (Alerto, 1993).

The concentration of hydrocyanic acid was 32.78mg/100g DW. The value observed was higher than 0.5mg/100g DW in the kernel of *Hasta la pasta* fruits (Hassan *et al.*, 2009). The value recorded was below 35mg/100g dry weight which is reportedly toxic (Isong *et al.*, 1999). Hydrocyanic acid poisons body haemoglobin making it unavailable for transporting oxygen. Lower dose may cause dizziness and headaches (ATSDR, 1997).

The level of nitrate was 0.64mg/100g DW. The observed value was lower than 13.50mg/100g DW in the seed of *Hasta la pasta* (Hassan *et al.*, 2009). The recorded value was lower compared to the acceptable daily intake level of 3 – 7mg/kg body weight equivalent of 220mg for 60kg person (WHO, 2002).

To predict the bioavailability of some divalent elements specifically calcium, magnesium, zinc and iron, antinutrients 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). Similarly [Ca] [phytate] / [Zn] ratio was below the critical level known to impair bioavailability of zinc (Umar, 2005). Also [phytate] / [Ca] ratio of the kernel was ($6.4x10^{-2}$). When compared to the critical level (0.2), the [phytate] / [Ca] are low compared to the critical value known to cause calcium deficiency by the phytate. The [phytate] / [Zinc] was higher than the critical value 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 5: Antinutritional composition of the seed kernel of *Sclerocarya birrea* fruits (mg/100g DW)

Antinutritional factors	Concentration
Phytate	423.09 ± 1.89
Total oxalate	67.56 ± 0.28
Hydrocyanic acid	32.78 ± 0.38
Tannins	3136.39 ± 3.85
Nitrate	0.64 ± 0.16

The data are mean value ± standard deviation of three replicates

Table 6: Antinutrients to Nutrients Molar Ratio

Antinutrients to Nutrients Ratio	Ratio (Kernel)	Critical level
[Oxalate] / [Ca]	7.5×10^{-2}	2.5
[Oxalate] / [Ca + Mg]	4.03×10^{-2}	2.5
[Ca] [Phytate] / [Zn]	1.25×10^{-1}	0.5
[Phytate] / [Ca]	6.4×10^{-2}	0.2
[Phytate] / [Fe]	1.31	0.4
[Phytate] / [Zn]	12.55	10

CONCLUSIONS

The analytical results have revealed that, the seed kernel is potentially a good source of protein, oil and some essential mineral elements especially calcium, potassium and magnesium which are found in high concentration. The antinutrients to nutrients molar ratio indicate that the kernel is relatively safe for consumption.

REFERENCES

Alan, W. (1996). Soil and the environment: An introduction, Cambridge University pres. Pp 49 – 80.

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.

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

ATSDR. (1997). US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. TOXFAQS.

Chadare, F. J., Linnemann, A. R., Hounhouigan, J. D., Nout, M.J.R and Van Boekel, M.A.J.S. (2009). Baobab Food Products: A Review on their Compositon and Nutritional Value. Critical Reviews in Food Science and Nutrition. 49: 254-274.

Engelter, C and Wehmeyer, A. S. (1990). Fatty acids composition of oils of some edible seed of wild plants. *Journal of Agriculture and Food Composition*. **18:** 25-26.

FAO. (1988). Non timber uses of some selected arid zone trees and shrubs in Africa. Food and Agricultural Organization, conservation guide 19, Rome. Pp.333.

Ganry, J. (2008). Promotion of fruits and vegetables in Countries of Sub-saharan Africa and the indian Oean. *Fruits* **63:** 63

Glew, R. S., Vanderjagt, D. J., Huang, Y. S. and Chuang, L. T. (2004). Nutritional analysis of the edible pit of *Sclerocarya birrea* in the Republic of Niger (daniya, Hausa). *Journal of Food Composition and Analysis* **17:** 99-111.

Hassan, L. G., Dangoggo, S. M., Hassan, S. W., Muhammad, S and Umar, K. J. (2010). Nutritional and antinutritional composition of *Sclerocarya birrea* fruit juice. *Nigerian Journal of Basic and Applied Sciences* **18(2):** 222 – 228.

Hassan, L. G., Dangoggo, S. M., Hassan, S. W., Muhammad, S and Umar, K. J. (2011). Serum biochemical response of rats fed with *Sclerocarya birrea* juice. *African Journal of Food Science* **5(4):** 208 – 212.

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 Journal*. **27(2):** 41-49.

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.

Ighodalo, C. E. and Catherine, O. E. (1991). Studies on the chemical composition and physicochemical properties of seeds of some wild plants. *Plant Foods and Human Nutrition* **41:** 252-258.

Isong, E. U., Adewus, S. A. B., N kanga, E. U., Umar, E. E. and Offiong, E. E. (1999). Nutritional evaluation of some legumes- based dishes consumed in Saudi Arabia. *International Journal of Food Sciences and Nutrition* **49:** 193-197.

James, C. A. (1995). *Analytical Chemistry of Food*. Chapman and Hill, London.

Kokwaro, J.O. and Gillett, J.B. (1980). Notes on the Anacardiaceae of East Africa. Kew Bull. **34(4):** 756.

Kokwaro, J.O. (1986). Flora of Tropical East Africa. A.A.Balkema, Rotterdam. C. Pp.206.

Krishna, G. and Ranjhan, S.K. (1980). Laboratory Manual For Nutrition Research. Vikas publishing House. PVK. Ltd, Ghaziabad, U.P (India) pp.121-123.

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

Marcelino, M., Samuel, C., Irma, L., Camacho, H., Antelmo, R and Francisco, D. (2005). Physicochemical and nutritional characteristics of the fruit of *Zizyphus sonorensis*. *International Journal of Food Sciences and Nutrition.* **56(8):** 587-596.

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

Ola, F.L and Oboh, G. (2000). Food value of two Nigerian edible Mushrooms(*Termitomycetes stratus and Termitomycetes robustus*). *The Journal of Technoscience* **4:**1-3.

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.

Palgrave, K.C. (1988). Trees of Southern Africa, Struck publishers. Cape Town. Pp-335.

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.

Umar, K.J. (2008). Nutritional Analyses of some wild leafy vegetables II. Proximate and amino acids composition I. A PhD seminar paper (unpublished). Usmanu Danfodiyo University, Sokoto.

Vainio-Maltila, K. (2000). Wild vegetables used by Sambaa in the Usambara Mountains, NE Tanzania. *Ann. Bot. Fennici* **37:** 57-98.

Van-Burden, T.P. and Robinson, W.C. (1981). Formation of complexes between protein and tannic acid. *Journal of Agricultural Food Chemistry*. **1:** 77.

Wenkam, A. (1990). Utilization and processing of fruits. Macmillan press. London. **5:** 388 – 398.

World Health Organization (WHO) (2002). Evaluation of certain food additives. Technical report series 913 (Geneva: WHO) pp. 20-32.