Ukwueze et al Comparison of the mineral value of African Yam Bean seeds grown from different Nigerian geographical locations

Ukwueze CALISTUS Kelechi
Ebonyi State University

Okereke CHUKWU Nkumah
Ebonyi State University

International Digital Organization for Scientific Research ISSN: 2550-7931
IDOSR JOURNAL OF APPLIED SCIENCES 2(3) 1-9, 2017.

Comparison of the mineral value of African Yam Bean seeds grown from different Nigerian geographical locations

[1]Ukwueze Calistus Kelechi, [2]Oladimeji Victor O., [1]Ukwueze Grace C. and [1]Okereke Chukwu Nkumah

[1]Department of Biological Science Faculty of Science Ebonyi State University Abakaliki, Nigeria.

[2]Department of Botany, University of Ibadan, Nigeria.

ABSTRACT

Nurseries were prepared at different locations in Nigeria which include Abakaliki, Enugu and Ibadan, with seeds of 13 genotypes of African Yam Bean collected from Gene bank of International Institute of Tropical Agriculture, Ibadan. At maturity, they were transplanted to permanent site to fit into Completely Randomized Design. The plants were staked two weeks after transplanting in clock-wise direction. The method of A.O.A.C (1990) was employed for the determination of mineral content of the harvested seeds. Potassium was the most abundant macronutrient followed by phosphorus, iron was the most abundant micronutrient followed by zinc. The seeds grown from Ibadan location showed high value across the genotypes than other locations while the genotypes performed averagely higher in Enugu than Abakaliki. In Abakaliki, TSs 58 is advised to be consumed while TSs 52 and TSs 57 could be given high preference for consumption in Enugu. In Ibadan, majority of the genotypes recorded high nutritional composition but high preference is given to TSs 57. Across the whole locations, TSs 57 from Ibadan could be given highest preference and TSs 58 from Enugu given least preference. Finally, this work showed that seeds of the same genotypes grown from different locations have varied nutritional composition.

Key words: genotype, macronutrient, micronutrient, *Sphenostylis stenocarpa.*

INTRODUCTION

Across nations, there has been an increased need for search of cheap and nutrient reach food to offset hunger among people, especially children and pregnant women. Increasing attention has been focused on a home grown legume crops whose seeds contain relatively high amount of nutrients. Here in Nigeria, legumes like cowpea, groundnut and to a less extent soybean have taken people's and researchers major concern. There are several other nutritious legumes that are lesser known but consumed by people.

African Yam Bean (*Sphenostylis stenocarpa*) is an under-utilized food legume crop in the tropics that is not popular as other major food legumes [1][2]. It is a climbing legume with exceptional ability to adapt to lowland tropical conditions. African Yam Bean belongs to family fabaceae and classified under the sub-family papilionoideae [3]. It is usually cultivated for its edible seeds and tuberous roots. Nutritionally, the seeds are known to possess high crude protein (21% to 29%) and approximately 50% carbohydrate [4][5], and among the amino acids lysine (9.28 g/ 16 g N) and methionine levels (1.16 g/ 16 g N) were either comparable or even better than those of soybean [6]. A couple of studies have been undertaken in African Yam Bean among which is genetic and environmental variation of seed yield and yield components in

African Yam Bean which I recently completed, but none has been on nutrients comparison of the seeds grown from different geographical locations in Nigeria.

Nutrients are the constituents in food that must be supplied to the body in suitable amounts [7]. Plants need the right combination of nutrients to live, grow and reproduce [8]. According to [9], macronutrients are those nutrients required in relatively large amounts while micronutrients are required in relatively small amounts. Among nutrients are minerals which are defined by [7], as those elements which remain largely as ash when plant and animal tissues are burnt. The human body contains more than 19 minerals, all of which must be derived from foods. According to him, a total of 4% of the body weight is made up of minerals. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur [10]. The macro-minerals are required in amounts greater than 100 mg/dl and the micro-minerals are required in amounts less than 100 mg/dl [11]. When plants suffer from malnutrition, they show symptoms of being unhealthy. Too little or too much of any one nutrient can cause problems. Micronutrient deficiencies are a major public health problem in many developing countries, with infants and pregnant women especially at risk [12]. To assess the dietary intake and adequacy of minerals, information needs to be collected on mineral element content of foods, diets and water [13][14]. There is limited information on the trace element content of water and numerous plant foods consumed in some less developed countries. Infants deserve extra concern because they need adequate micronutrients to maintain normal growth and development [15]. Since the condition of health of individual is influenced by the availability and utilization of nutrients in the consumed food, there is need for researchers to start comparing the quantity and quality of nutrients, precisely minerals of plant's products produced from different locations.

Therefore, this study is aimed at evaluating the mineral content and its comparison of African Yam Bean grown from three different locations in Nigeria namely Abakaliki, Enugu and Ibadan.

Materials and Method

Materials

Seeds of 13 genotypes of AYB were collected from the Gene bank of the International Institute of Tropical Agriculture (IITA), Ibadan. The genotypes include TSs 10, TSs 23, TSs 45, TSs 52, TSs 57, TSs 58, TSs 61, TSs 86, TSs 96, TSs 131, TSs 163, TSs 368 and TSs 373. 50 sticks of 3 m length were assembled per location for staking. Three locations were chosen; Enugu, Abakaliki and Ibadan.

Method

This experiment was conducted during 2012/2013 raining season. Nurseries were prepared first in each location by filling the pots with soil, 2 seeds were sown per pot. The nurseries were irrigated at regulated interval. The sites were mapped out and measured 15 m × 12 m, cleared and ridged with the spacing of 1m between ridge tops. When the nurseries have fully produced their third set of leaves, the plants were transplanted to the permanent site on the ridges, and the genotypes arranged on the field to ensure clarity in genotype's identification. The plants were staked two weeks after transplanting in clock-wise direction using sticks of about 3 m length. At interval, the sites were weeded manually and fumigated with insecticide using the dosage of 160g full of insecticide called Attack per 20 litres of water per site. At maturity, the pods were carefully harvested and the extracted seeds labeled before it's taken to the laboratory for analysis.

Nutrients Analysis

The method of [16] was employed for the determination of mineral content. One gram of the pulverized seed samples was placed in a crucible and ignited in a muffle furnace at 550OC for 6 hours. The resulting ash was dissolved in 10 ml of 10 % HNO3 and heated slowly for 20 minutes. After heating, filter and the filtrate was used for the determination of mineral content. Atomic absorption spectrophotometer (AAS) was used to determine Ca, Mg, Fe, P, Cu, Mn and Zn, while flame photometer was used for the determination of K in the filtrate.

Result and Discussion

Table 1: Mineral composition of African Yam Bean seeds grown from Abakaliki Experimental site

	%Ca	%K	%Mg	%P	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
TSs 10	0.128	1.309	0.141	0.307	15.6	50.2	24.3	33.4
TSs 23	0.132	1.376	0.144	0.315	14.7	50.6	25.1	35.2
TSs 45	0.138	1.235	0.149	0.289	15.5	50.4	22.1	31.6
TSs 52	0.136	1.218	0.136	0.267	14.8	50.4	29.2	33.6
TSs 57	0.135	1.233	0.146	0.292	14.1	49.5	21.6	30.9
TSs 58	0.167	1.477	0.183	0.321	17.9	55.4	34.2	35.8
TSs 61	0.163	1.521	0.172	0.329	17.5	54.5	31.2	37.5
TSs 86	0.123	1.226	0.131	0.287	14.8	48.5	23.3	31.6
TSs 96	0.131	1.231	0.144	0.296	15.3	49.1	22.8	31.3
TSs 131	0.125	1.304	0.136	0.291	15.1	49.3	23.6	32.7
TSs 163	0.138	1.394	0.151	0.306	15.9	51.2	24.5	31.6
TSs 368	0.129	1.241	0.138	0.294	15.1	50.7	23.5	32.3
TSs 373	0.137	1.397	0.146	0.303	15.4	51.5	25.3	35.6

From Table 1, it was observed that Potassium is the most abundant macro-mineral followed by phosphorus. This is in accordance with the finding of [17]. Calcium and magnesium are generally low across the varieties. TSs 58 showed the highest percentage as it was followed by TSs 61 in calcium, cupper, iron, manganese and magnesium, TSs 61 inversely showed the highest value in potassium, phosphorus and zinc as it was followed by TSs 58. For calcium, magnesium, and iron, the least value was shown by TSs 86. In copper and zinc, the least percentage was shown by TSs 57. TSs 52 showed the least percentage in potassium and phosphorus whereas TSs 45 was found as the least in Mn. Some genotypes showed similarity in mineral composition like TSs 45 and TSs 163 under calcium, TSs 23 and TSs 96, TSs 52 TSs 131 as well as TSs 57 and TSs 373 under Mg.

In Table 2, Potassium is the most abundant macro-mineral followed by phosphorus as it was observed in Table 1. TSs 57 showed highest percentage of nutrients under calcium, magnesium, phosphorus and iron. TSs 52 showed highest percentage under potassium, copper and magnesium even as TSs 10 had highest constitution in zinc with very high significant value in potassium, phosphorus, copper and manganese.

TSs 58 showed least in mineral constitution under potassium, magnesium, phosphorus, copper, iron and manganese.

Table 2: Mineral composition of African Yam Bean seeds grown from Enugu experimental location.

	%Ca	%K	%Mg	%P	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
TSs 10	0.158	1.487	0.158	0.341	16.3	51.8	32.5	37.6
TSs 23	0.143	1.412	0.154	0.313	15.7	53.7	25.8	36.3
TSs 45	0.141	1.405	0.153	0.297	16.3	46.2	24.6	33.8
TSs 52	0.162	1.503	0.162	0.329	16.7	52.7	32.8	36.9
TSs 57	0.173	1.456	0.169	0.349	15.6	57.8	26.7	36.9
TSs 58	0.123	1.216	0.123	0.267	12.8	45.2	21.8	28.6
TSs 61	0.131	1.326	0.137	0.292	15.2	47.3	24.2	30.8
TSs 86	0.134	1.387	0.149	0.301	14.9	49.9	24.8	31.2
TSs 96	0.134	1.395	0.143	0.302	15.3	50.9	24.2	31.8
TSs 131	0.118	1.228	0.134	0.282	13.6	48.3	22.3	31.4
TSs 163	0.138	1.408	0.151	0.307	14.8	45.8	25.3	34.6
TSs 368	0.123	1.234	0.129	0.287	13.3	46.9	22.8	28.6
TSs 373	0.126	1.246	0.125	0.279	13.8	45.6	23.1	27.8

Under calcium, TSs 131 showed least constitution as TSs 373 showed least constitution in zinc. TSs (45, 52, 23 and 57) showed significantly high value in some of the minerals composition.

Table 3 has high percentage shown by TSs 57 under magnesium, phosphorus and copper with a very high significant value in calcium, potassium, iron and manganese. Potassium is the most abundant macronutrient followed by phosphorus as shown in previous tables. TSs 58 showed high values in calcium, potassium and manganese with high significant value under magnesium and phosphorus. Under iron and zinc, TSs 373 and TSs 45 respectively showed

Table 3: Mineral composition of African Yam Bean seeds grown from Ibadan experimental location.

	%Ca	%K	%Mg	%P	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
TSs 10	0.172	1.525	0.172	0.336	17.5	53.2	33.4	38.5
TSs 23	0.147	1.482	0.156	0.323	16.5	52.3	26.4	36.1
TSs 45	0.175	1.544	0.183	0.367	19.1	56.8	29.6	39.5
TSs 52	0.169	1.523	0.169	0.331	17.2	54.8	33.2	37.6
TSs 57	0.186	1.554	0.197	0.381	20.4	58.4	34.6	36.3
TSs 58	0.192	1.561	0.192	0.375	19.6	54.7	34.7	37.2
TSs 61	0.129	1.318	0.142	0.294	14.5	49.5	23.6	29.2
TSs 86	0.138	1.536	0.163	0.309	16.8	52.8	25.2	34.6
TSs 96	0.129	1.383	0.139	0.298	15.1	47.1	23.9	28.8
TSs 131	0.181	1.549	0.192	0.372	20.1	55.9	33.8	38.2
TSs 163	0.174	1.518	0.174	0.334	17.8	55.2	33.6	38.2
TSs 368	0.144	1.463	0.165	0.311	17.2	53.1	26.1	35.2
TSs 373	0.159	1.486	0.178	0.328	18.3	58.6	28.4	37.3

the highest percentage. Under calcium, potassium, phosphorus, copper and manganese, their least value was shown by TSs 61 as TSs 96 showed least value in Mg, Fe and zinc. TSs 131 showed high significant value under magnesium and copper. Under zinc, a significant value was observed in TSs 10, the same with TSs 57 under calcium, potassium, iron and manganese.

Table 4 showed that among the 3 locations, Ibadan showed highest mineral constitution across the whole parameters analysed. Majority of the seeds from Ibadan location also showed high value across the genotypes when compared to mineral value of the seeds from Abakaliki and Enugu. Although [18] reported values of 0.10% for Calcium and 0.30% for phosphorus in edible leguminous seeds and they are classified as poor sources of these two essential minerals. But across the three locations, the values reported for phosphorus and calcium in the present work showed that all varieties had higher constitution. TSs 57 showed high mineral value across the whole location as it was followed by TSs 58. Enugu showed higher mineral constitution than Abakaliki in parameters Ca (TSs 57), P (TSs 57), Fe (TSs 57), and Zn (TSs 58) while Abakaliki topped Enugu in parameters like K (TSs 61), Mg (TSs 58), Cu (TSs 58) and Mn (TSs 58). Trace elements of significance to people with HIV are zinc and selenium. Selenium is an antioxidant that increases immune function. Zinc, usually taken to stimulate the immune system, has been reported to weaken immune system function and lower calcium levels in HIV – positive men [19][20]. Therefore, the seeds from Enugu and preferably Abakaliki could be mineral certified for HIV patients because of their low composition of zinc. TSs 58 showed the least mineral constitution in Enugu locations under the parameters like potassium, magnesium, copper, iron and manganese.

Table 4: Comparison of mineral composition of African Yam Bean seeds grown from the three experimental locations.

	Location	%Ca	%K	%Mg	%P	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
TSs 10	Abakaliki	0.128	1.309	0.141	0.307	15.6	50.2	24.3	33.4
	Enugu	0.158	1.487	0.158	0.341	16.3	51.8	32.5	37.6
	Ibadan	0.172	1.525	0.172	0.336	17.5	53.2	33.4	38.5
TSs 23	Abakaliki	0.132	1.376	0.144	0.315	14.7	50.6	25.1	35.2
	Enugu	0.143	1.412	0.154	0.313	15.7	53.7	25.8	36.3
	Ibadan	0.147	1.482	0.156	0.323	16.5	52.3	26.4	36.1
TSs 45	Abakaliki	0.138	1.235	0.149	0.289	15.5	50.4	22.1	31.6
	Enugu	0.141	1.405	0.153	0.297	16.3	46.2	24.6	33.8
	Ibadan	0.175	1.544	0.183	0.367	19.1	56.8	29.6	39.5
TSs 52	Abakaliki	0.136	1.218	0.136	0.267	14.8	50.4	29.2	33.6
	Enugu	0.162	1.503	0.162	0.329	16.7	52.7	32.8	36.9
	Ibadan	0.169	1.523	0.169	0.331	17.2	54.8	33.2	37.6
TSs 57	Abakaliki	0.135	1.233	0.146	0.292	14.1	49.5	21.6	30.9
	Enugu	0.173	1.456	0.169	0.349	15.6	57.8	26.7	36.9
	Ibadan	0.186	1.554	0.197	0.381	20.4	58.4	34.6	36.3
TSs 58	Abakaliki	0.167	1.477	0.183	0.321	17.9	55.4	34.2	35.8
	Enugu	0.123	1.216	0.123	0.267	12.8	45.2	21.8	28.6
	Ibadan	0.192	1.561	0.192	0.375	19.6	54.7	34.7	37.2
TSs 61	Abakaliki	0.163	1.521	0.172	0.329	17.5	54.5	31.2	37.5
	Enugu	0.131	1.326	0.137	0.292	15.2	47.3	24.2	30.8
	Ibadan	0.129	1.318	0.142	0.294	14.5	49.5	23.6	29.2
TSs 86	Abakaliki	0.123	1.226	0.131	0.287	14.8	48.5	23.3	31.6
	Enugu	0.134	1.387	0.149	0.301	14.9	49.9	24.8	31.2
	Ibadan	0.138	1.536	0.163	0.309	16.8	52.8	25.2	34.6
TSs 96	Abakaliki	0.131	1.231	0.144	0.296	15.3	49.1	22.8	31.3
	Enugu	0.134	1.395	0.143	0.302	15.3	50.9	24.2	31.8
	Ibadan	0.129	1.383	0.139	0.298	15.1	47.1	23.9	28.8
TSs 131	Abakaliki	0.125	1.304	0.136	0.291	15.1	49.3	23.6	32.7
	Enugu	0.118	1.228	0.134	0.282	13.6	48.3	22.3	31.4
	Ibadan	0.181	1.549	0.192	0.372	20.1	55.9	33.8	38.2
TSs 163	Abakaliki	0.138	1.394	0.151	0.306	15.9	51.2	24.5	31.6
	Enugu	0.138	1.408	0.151	0.307	14.8	45.8	25.3	34.6
	Ibadan	0.174	1.518	0.174	0.334	17.8	55.2	33.6	38.2
TSs 368	Abakaliki	0.129	1.241	0.138	0.294	15.1	50.7	23.5	32.3
	Enugu	0.123	1.234	0.129	0.287	13.3	46.9	22.8	28.6
	Ibadan	0.144	1.463	0.165	0.311	17.2	53.1	26.1	35.2
TSs 373	Abakaliki	0.137	1.397	0.146	0.303	15.4	51.5	25.3	35.6
	Enugu	0.126	1.246	0.125	0.279	13.8	45.6	23.1	27.8
	Ibadan	0.159	1.486	0.178	0.328	18.3	58.6	28.4	37.3

It also showed equivalent least constitution in Enugu and Abakaliki. Under calcium and zinc, TSs 131 and TSs 373 respectively, both from Enugu location showed least constitution. High calcium content of seeds from Ibadan could help limit the consequences of calcium deficiency which are rickets in children, osteomalacia in adult, increase in irritability of nerve tissue, spontaneous discharges of nerve impulses leading to tetany and convulsions [21][22][11]. Its high phosphorus constitution suggests that the plant experienced early growth and hastened maturity than other locations [23]. In human, it could help in many metabolic processes, including those involving the buffers in body fluids [21]. Unlike the seeds from Enugu and Abakaliki locations, the seeds from Ibadan location will help more in limiting the occurrence of deficient diseases of potassium in humans which include impaired neuromuscular functions of skeletal, smooth, and cardiac muscle, muscular weakness, paralysis, mental confusion [21][22][11]. Its increased potassium could also help in reduction of occurrence of alterations of gastric secretions and intestinal motility [24]. When a magnesium-deficient diet is fed to young chicks, it leads to poor growth and feathering, decreased muscle tone, ataxia, progressive incoordination and convulsions followed by death [25]. So Ibadan seeds could assist more in preparation of feeds for animals and also as food for humans since magnesium deficiency in humans include depressed deep tendon reflexes and respiration [11]. [26] reported that clinical disorders associated with Cu deficiencies include anaemia, bone disorders, neonatal ataxia, depigmentation and abnormal growth of hair, fur or wool, impaired growth and reproductive performance, heart failure and gastrointestinal disturbances while manganese deficiency presents with the following signs; in pigs, lameness, enlarged hock joints, and shortened legs, in cattle, leg deformities with over knuckling, in chicks, poults and ducklings, perosis or slipped tendon; and in chick embryos, nutritional chondrodystrophy. Fe deficiency is associated with alterations in many metabolic processes that may impact brain functioning, among whom are neurotransmitter metabolism, protein synthesis, organogenesis etc [27]. The occurrence of these deficiencies could be curbed by consuming food with high mineral constitution like AYB seeds from Ibadan.

Conclusion

This study has been able to explore the mineral differences among seeds of African Yam Bean (*Sphenostylis stenocarpa*) grown from three different locations in Nigeria including Abakaliki, Enugu and Ibadan. The genotypes generally performed higher with less variation in Ibadan site than other locations. While between Enugu and Abakaliki, the genotypes performed averagely higher in Enugu. In Abakaliki, TSs 58 is advised to be consumed because of its high mineral content. In scarcity of TSs 51, TSs 61 could be used as substitute as it has high mineral composition also while least preference could be given to TSs 86. In Enugu, TSs 52 and TSs 57 could be given high preference for consumption while TSs 58 could be given least preference because of their mineral composition. In Ibadan, majority of the genotypes recorded high mineral composition but high preference is given to TSs 57, and also to TSs 58 in limited supply of TSs 57. But least preference could be given to TSs 61. Across the whole locations, TSs 57 from Ibadan could be given highest preference and TSs 58 from Enugu given least preference. Finally, this work has been able to show that seeds of the same genotypes grown from different locations have varied mineral composition.

Acknowledgement

This work would not have been successful without the blessings and support of God, The authors sincerely thank Him.

References

1 M. A. Azeke, F. Barbara, B. P. Han, H. Wilhelm, and B. Thomas, Nutritional value of African Yam Bean (*Sphenostylis stenocarpa*): Improvement by lactic acid fermentation, *J. Sci. Food Agric., 85(6)*, 2005, 963-970.

2 O. K. Moyib, M. A. Gbadegesin, O. O. Aina, and A. O. Odunola, Genetic variation within a collection of Nigerian accessions of African Yam Bean (*Sphenostylis stenocarpa*) revealed by RAPD primers. *African Journal of Biotechnology, 7*, 2008, 1839 -1846.

3 V. H. Heywood, The leguminosals systematic purview, In *Chemotaxomy of leguminosae*. Harborne, J. B., D. Bontler and R. L. Turner (Eds.). Academic Press Inc., London, 1971, pp. 1-23.

4 B. N. Okigbo, Introducing the yam bean (*Sphenostylis stenocarpa*). *J Food Sci 54,* 1973, 758–759.

5 C. O. Eromosele, L. A. Arogundade, I. C. Eromosele, and O. Ademuyiwa, Extractability of African yam bean (*Sphenostylis stenocarpa*) protein in acid, salt and alkaline aqueous media. *Food Hydrocoll 22,* 2008, 1622–1628.

6 M. Evans, and D. Boulter, Amino acid composition of seed meals of yam bean (*Sphenostylis stenocarpa*) and lima bean (*Phaseolus lunatus*). *J Sci Food Agric. 25,* 1974, 919–22.

7 Vikram, *Concept of health and nutrition in community*, 2009.

8 S. Hosier, and L. Bradley, Guide to symptoms of plant nutrient deficiencies. *The University of Arizona Cooperative Extension*. 1999, ag.arizona.edu/pubs/garden/az1106.pdf

9 M. Little, *The mineral nutrition of plant*, 2008.

10 D. Eruvbetine, *Canine Nutrition and Health*. A paper presented at the seminar organized by Kensington Pharmaceuticals Nig. Ltd., Lagos on August 21, 2003.

11 R. K. Murray, D. K. Granner, P. A. Mayes, and V. W. Rodwell, *Harper's Biochemistry* (25th Edition, McGraw-Hill, Health Profession Division, USA, 2000).

12 J. Batra, and P. K. Seth, Effect of iron deficiency on developing rat brain. *Indian J. Clin. Biochem. 17*(2), 2002, 108-114.

13 C. N. Rao, and B. S. N. Rao, Trace element content of Indian foods and the dietaries. *Indian J. Med. Res. 73*, 1981, 904-909.

14 A. Simsek, and O. Aykut, Evaluation of the microelement profile of Turkish hazelnut (*Corylus avellana* L) varieties for human nutrition and health. *Int. J. Food Sci. Nutr. 58*, 2007, 677-688.

15 D. Rush, Nutrition and Maternal mortality in the developing world, *Am. J. Clin. Nutr. 72*, 2000, 2125-2405.

16 A. O. A. C. *Official Methods of Analysis* (14th edn [Arlington] Association of Official Analytical Chemist 1990).

17 D. F. Apapa, and A. D. Ologhobo, Some aspect of the biochemistry and nutritive value of African Yam Bean seeds (*Sphenostylis stenocarpa*). *Food Chemistry. 36*, 1990, 271-280.

18 R. Bressani, and L. G. Elias, *In new protein foods* (A. M. Altschul (Ed). New York. P. 230, 1974).

19 B. B. O' Connor, Vernacular health care response to HIV and AIDS. *Alternative Therapies 1*(5), 1995, 35-52.

20 R. J. Wood, Assessment of marginal zinc status in humans. *J. Nutr. 130*, 2000, 1350-1354.

21 V. W. Hays, and M. J. Swenson,. Minerals and Bones. In *Dukes' Physiology of Domestic Animals*, Tenth Edition, 1985, pp. 449-466.

22 V. K. Malhotra, *Biochemistry for Students* (New Delhi, India: Jaypee Brothers Medical Publishers [P] Ltd, 1998).

23 S. Sharma, P. Mahotra, and A. K. Bhattacharyya, Effect of electroplating industrial waste on ''available phosphorus'' of soil in relation to other physico-chemical properties. *Afr. J. Environ. Sci. Technol. 2*(*9*), 2008, 257-264.

24 D. H. P. Streeten, and E. M. V. Williams, Loss of cellular potassium as a cause of intestinal paralysis in dogs. *J. Physiol. 118*, (1952), 149-170.

25 V. M. Merck, *The Merck Veterinary Manual*. (Rahway, New Jersey, USA: Merck and Co. 1986).

26 K. O. Soetan, C. O. Olaiya, and O. E. Oyewole, The importance of minerals for humans, domestic animals and plants: A review. *African Journal of Food Science 4* (*5*), 2010, 200-222.

27 J. L. Beard, Iron deficiency and neural development: an update Arch. *Latinoam Nutr. 49*(3 Suppl. 2), 1999, 34-39.