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Mineral Content of Some Plant Foods Grown in Nigeria: A Review

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Abstract

Minerals are natural inorganic substances that possess definite chemical composition and atomic structure. Nearly five percent of the body is composed of inorganic materials, the minerals. Minerals do not serve as a source of energy for the body but have specific chemical functions. For this purpose, mineral content of some plant foods found in Nigeria were critically reviewed. The plant foods were classified into legumes (*Vigna unguiculata, Cucurbitaceae, vigna subterranean, Arachis hypogeal, Glycine max, Phaseolus coccineus, Cajanus cajan, Kerstingiella geocarpa, Phaseolus vulgaris L., Phaseolus lunatus* and *Prosopis Africana*); cereals (*Zea mays, Sorghum bicolor, Pennisetum typhoides* and *Oryza sativa*); roots and tubers (*Dioscorea spp, Manihot esculanta, Xanthosoma sagititolium* and *Ipomoea batatas L.*); fruits/vegetables/nuts (*Musa spp, Psidium guajava, Carica papaya, Citrus sinensis, Ananus comosus, Malaudo mistica, Anarcardium occidentale, Veronia amygdalina L.* and *Dacryodes edulis*). Atomic absorption spectrophotometric (AAS) method is used for the minerals determination except sodium and potassium which are usually determined using flame photometry while phosphorus is by using colorimetry. The mineral contents were found to be at the range of concentrations as Ca: 0.003 – 700.00, Mg: 0.0546 – 1420.10, Na: 0.0065 – 220.00, K: 0.010 – 817.40, P: 0.0130 – 5500.00 and Fe: 0.0067 – 36.00 mg/100g for legumes; Ca: 0.13 – 8490.00, Mg: 0.006 – 4571.00, Na: 0.019 – 375.69, K: 0.63 – 39856.00, P: 3.54 – 695.50 and Fe: 0.0005 – 1304.00 mg/100g for fruits/vegetables/nuts; Ca: 1.05 – 290.00, Mg: 0.49 – 415.07, Na: 0.18 – 1365.05, K: 0.50 – 4276.04, P: 0.28 – 120.00 and Fe: 0.53 – 81.85 mg/100g for roots and tubers and Ca: 0.005 – 532.00, Mg: 1.54 – 348.30, Na: 0.006 – 520.00, K: 0.011 – 618.00, P: 73.00 – 46.30 mg/100g for cereals. Microelement concentrations of the foods varied appreciably. Zinc content was highest in *Vigna unguiculata*, *Psidium guajava*, *Manihot esculanta* and *Zea mays* with values of 162.00, 2209.00, 340.00 and 16.70 mg/100g, respectively. Legumes and fruits/vegetables/nuts are seen to be better sources of mineral than foods in the category of roots, tubers and cereals.

Keywords: Legumes, cereals, fruits, vegetables, snuts, roots, tubers, minerals.

1. Introduction

Minerals are natural inorganic substances that possess definite chemical composition and atomic structure, and nearly five percent of human body is composed of inorganic materials, the minerals (Aremu *et al.*, 2005a, Cornelis and Halbut, 1985). They are present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. Minerals are chemical constituents used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body (Malhotra, 1998, Eruvbetine, 2003). Every form of living matter requires these inorganic elements or minerals for their normal life processes though some of these elements cause a health hazard when foods containing them are ingested (Aremu *et al.*, 2005b, Ozcan, 2003). Most minerals are obtained as inorganic ions, except for nitrogen (N) and sulphur (S), which are obtained predominantly as components of amino acids and other organic molecules, or for phosphorus (P), which is obtained in nucleotides, nucleic acids and phosphor lipids (Micheal, 2003).

Minerals may be broadly classified as macro (major) or micro (trace) elements. The third category is the ultra trace elements. 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 (Eruvbetine, 2003). 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 (Murray *et al.,* 2000). The ultra trace elements include boron, silicon, arsenic and nickel which have been found in animals and are believed to be essential for these animals. Evidence for requirements and essentialness of others like cadmium, lead, tin, lithium and vanadium is weak (Albion Research Notes, 1996).

Good nutrition is a basic human right. In order to have a healthy population that can promote development, the relation between food, nutrition and health should be reinforced. In developing countries, one of the ways of achieving this is through the exploitation of available local resources, in order to satisfy the needs of the increasing population. The mineral elements are separate entities from the other essential nutrients like proteins, fats, carbohydrates, and vitamins (Hegsted *et al.,* 1976). In this century, biological assay methods clarified the significance and importance of mineral elements for human and animal nutrition and modern analytical techniques led to the detection of trace elements as essential nutrients and this is still an active area of current research.

Micronutrient deficiencies are a major public health problem in many developing countries, with infants and pregnant women especially at risk (Batra and Seth, 2002). Infants deserve extra concern because they need adequate micronutrients to maintain normal growth and development (Rush, 2000). The micronutrient deficiencies which are of greatest public health significance are iron deficiency, causing varying degrees of impairment in cognitive performance, lowered work capacity, lowered immunity to infections, pregnancy complications e.g. babies with low birth weight, poor learning capacity and reduced psychomotor skills (Batra and Seth, 2002). Medical reports show that very severe anaemia is a direct cause of maternal and child mortality (Chakravarty and Ghosh, 2000). There have been suggestions that more than anything else, lack of adequate information about the composition of varied feed resources in some regions have been the major drawback to their utilization, rather than real shortage (Aletor and Omodara, 1994). For instance, there is very limited information on the mineral elements in some plants used as human food and animal feeds consumed in Nigeria, especially the newly introduced varieties of diets and the lesser known legumes. Some of the earlier information on mineral elements was based on analysis employing less sensitive methods, which may not be reliable (Seotan *et al.,* 2010; Aremu *et al.,* 2010).

Minerals are critical in the regulation of a number of cell membrane, permeability, muscles contraction, heart function, blood clothing, protein synthesizing and red blood synthesis (Aremu *et al.,* 2005a, Hendricks, 2002). For examples, calcium in conjunction with phosphorus, magnesium, manganese, vitamin A, C and D, chloride and protein, are all involved in bone formation (Fleck, 1976). Calcium is also important in blood clotting, muscle contraction and in certain enzymes metabolic processes (Aremu *et al.,* 2005a). Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Shills, 1973). Phosphorus assists calcium in many body reactions although it also has independent function (Fleck, 1976). Sodium and potassium are required to maintain osmotic balance of the body fluids, pH of the body, regulate muscle and nerve irritability and control of glucose absorption (Shills, 1973, Pike and Brown, 1967). Iron is reported to be very important for normal functioning of the central nerve system (Vyas and Changra, 1984). Iron also facilitates the oxidation of carbohydrates, proteins and fats (Aremu *et al.,* 2005a). Zinc is present in all tissues of the body and it is a component of more than fifty enzymes. Consumption of meat (or other animal products) with vegetables enhances the absorption of both iron and zinc (Bender, 1992).

There has been an increase in consumption of cereals (e.g. rice, guinea corn, millet and maize); roots and steam tubers (e.g. yam, cassava, potato, etc) and fruits (e.g. pawpaw, guava, banana, etc) in Nigeria. The reason is due to the fact that they are grown locally and are easily affordable. Some tribes in Nigeria are used to a particular types of food material that they only vary the cooking procedures and eat it many times a day. Thus, yam can be eaten as boiled yam in the morning, prepared yam flour called 'amala' in Yoruba land in the afternoon and as pounded yam in the evening. In these varied forms, yam can be eaten three times a day for several days. This practice can result in high dietary intake for some minerals and low intake for another. In recent years, poor economy in Nigeria has contributed immensely to the poor consumption of animal products hence, some people particularly the low-income earners rely mainly on minerals obtained from plant materials (Oluyemi *et al.,* 2005, Adewusi *et al.,* 1999; Aremu *et al.,* 2009).

2. Mineral Content in Plant Foods

Minerals do not serve as a source of energy for the body but have specific chemical function (Crossby, 1977). To date, nutritional scientists have identified sixteen minerals that are essential to maintain good health and promote proper metabolism and other functions primarily as structural elements (in teeth, muscles, haemoglobin and thyroid hormones) (Bran and Allan, 1975). Cereals, root and steam tubers, vegetables and fruits have been shown to contain such elements as Na, K, Ca, Zn, Cu, Fe, Cl, etc which are considered quite essential for proper health and growth of human. They are needed in balanced diets like essential amino acid (Health and Welfare, 1982). Most of these elements are important part of enzymes. It has been reported that deficiency of essential minerals usually leads to skeletal deformities, growth retardation and other ill health conditions (Sandstead, 1975). Studies on metals have revealed their functions in plants and animals which include their role in osmotic regulations of the body fluids, enhance growth, ensure healthy crops and animals, act as coenzyme and information of chlorophyll.

3. Methods of Analysis for the Minerals

Mineral elements in plant and soil samples are essentially estimated by colorimetric procedure according to the method described by Sandell (1959). The wet-ashing procedure of Gorsuch (1959) using nitric acid, perchloric acid and sulphuric acid in the ratio of 3:2:1 is usually employed for the digestion of the food samples. Processing of samples of foods and water for mineral analysis is carried out in a dust-free room to avoid contamination, using distilled deionized water for all dilutions (Rao and Rao, 1981). Appropriate blanks are also included along with the samples and trace elements are estimated in the samples using an atomic absorption spectrophotometer. Internationally approved standards are also run along with the samples to be analysed to check the results obtained. Studying the chemical composition of plants provide clues about their nutritional requirements (Roberts, 1985).

4. Mineral Content of some Nigerian Plant Foods

The mineral compositions in mg/100g of some legumes grown in Nigeria are presented in Tables 1a&b. The abundant minerals in the reviewed samples were phosphorus and magnesium with values ranging from 0.013 – 5500.00 mg/100g and 0.0644 – 1240.10 mg/100g respectively. These followed by potassium (0.010 – 817.40 mg/100g) and calcium (0.003 – 700.00 mg/100g) while the least concentrated mineral was manganese (0.0010 – 36.20 mg/100g). The values in mg/100g sample of other essential minerals in the legumes samples were; sodium ranged between 0.0069 to 208.00 mg/100g sample, zinc (0.0074 – 162.00 mg/100g), iron (0.0067 – 80.00 mg/100g) and copper (0.0001 – 57.00 mg/100g). Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin and also takes part in milk clotting. It plays a vital role in enzyme activation. Calcium activates large number of enzymes such as adenosine triphosphatase (ATPase), succinic dehydrogenase, lipase, etc (Seotan *et al.,* 2010). Phosphorus is located in every cell of the body and is vitally concerned with many metabolic processes, including those involving the buffers in the body fluids (Hays and Swenan, 1985). It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It serves buffering action, that is, phosphate buffers, functions in the formation of high energy compounds, that is, ATP and is involved in the synthesis of phospholipids and phosphoproteins (Murray *et al.*, 2000).

Table 1a: Mineral Composition (mg/100g) of some legumes found in Nigeria

Legumes	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/(Ca+Mg)	Authors
Cowpea	0.51	8.67	19.53	17.68	-	1.04	-	0.34	-	-	0.03	0.63	Owolabi *et al.*, 2012
(*Vigna unguiculata*)	0.41	9.00	17.15	18.69	-	0.48	-	0.43	-	-	0.02	0.71	Owolabi *et al.*, 2012
	-	128.54	582.00	-	645.00	4.60	6.13	-	-	0.90	-	-	Chinma *et al.*, 2008
	-	136.40	424.00	-	539.00	4.82	6.00	-	-	0.79	-	-	Chinma *et al.*, 2008
	-	142.00	471.00	-	445.05	4.00	5.93	-	-	1.06	-	-	Chinma *et al.*, 2008
	-	145.12	545.00	-	463.00	4.45	5.55	-	-	1.18	-	-	Chinma *et al.*, 2008
	6.90	67.70	59.40	35.70	8.30	5.50	0.30	5.70	1.20	7.16	0.19	0.28	Aremu *et al.*, 2006a
	6.50	54.60	66.40	40.40	13.00	6.70	0.30	6.00	1.20	5.11	0.16	0.33	Aremu *et al.*, 2006a
	120.00	95.00	44.00	100.00	2940.00	80.00	57.00	162.00	ND	0.01	1.20	0.72	Arawande and Borokini, 2010
	3.81	1.89	1.63	4.00	-	0.59	0.53	2.01	1.12	-	0.95	1.14	Oluyemi *et al.*, 2005
	5.33	3.24	3.03	5.12	-	1.14	0.97	3.08	3.04	-	1.04	0.82	Oluyemi *et al.*, 2005
	0.0065	0.0546	0.0664	0.0405	0.0130	0.0067	0.0003	0.0012	0.0012	5.10	0.16	0.33	Aremu *et al.*, 2006b
	197.70	375.00	214.30	258.70	36.70	2.90	0.43	18.13	0.23	5.84	0.76	0.44	Aremu *et al.*, 2005a
Melon (*Cucurbitaceae)*	1.75	1.10	1.90	2.85	-	0.10	0.10	0.31	0.02	-	0.61	0.95	Akpambang *et al.*, 2008
	1.85	1.05	1.65	2.75	-	0.10	0.10	0.31	0.02	-	0.67	1.02	Akpambang *et al.*, 2008
	2.71	5.91	0.59	2.15	-	1.11	0.26	0.75	ND	-	1.26	0.33	Fagbohun *et al.*, 2011
	1.85	1.15	1.79	2.80	-	0.10	0.10	0.33	0.02	-	0.66	0.95	Jackson *et al.*, 2013
	1.75	1.10	1.90	2.65	-	0.11	0.10	0.30	0.02	-	0.66	0.88	Jackson *et al.*, 2013
	1.78	6.75	0.80	2.51	-	1.32	0.06	0.49	ND	-	0.71	0.33	Lawal, 2011
	6.18	5.21	0.99	5.28	-	1.23	1.93	3.64	2.07	-	1.17	0.85	Oluyemi *et al.*, 2005
	13.00	31.40	28.20	96.10	125.30	1.30	0.40	1.20	1.70	0.23	0.14	1.16	Ojieh *et al.*, 2008
Bambara groundnut (*Vigna*	7.40	57.30	60.20	33.50	-	5.90	0.12	5.30	1.80	-	0.22	0.29	Aremu *et al.*, 2006c
subterranea)	10.60	58.00	63.80	42.70	-	4.70	0.12	3.90	2.30	-	0.25	0.35	Aremu *et al.*, 2006c
	7.40	57.30	60.20	33.50	32.50	5.90	0.10	5.30	1.80	1.85	0.22	0.29	Aremu *et al.*, 2006a
	10.60	58.00	63.80	42.70	26.50	4.70	0.10	3.90	2.30	2.41	0.25	0.35	Aremu *et al.*, 2006a
	208.00	509.00	524.00	431.70	72.30	5.50	0.34	3.97	3.60	7.25	0.48	0.42	Aremu *et al.*, 2005a
	6.20	8.00	85.50	237.33	7.43	4.57	1.25	2.36	1.96	11.51	0.03	2.54	Ujowundu, 2013
	8.67	360.00	700.00	210.00	7.98	6.98	0.98	1.22	5.48	87.72	0.04	0.20	Abiodu and Adepeju, 2011

	2.15	180.00	350.00	120.00	4.74	2.63	0.23	0.55	1.80	73.84	0.02	0.23	Abiodu and Adepeju, 2011
	-	-	-	-	-	8.30	1.90	2.70	2.60	-	-	-	Aremu *et al.*, 2006d

ND = Not detected; **–** = not available

Table 1b: Mineral Composition (mg/100g) of some legumes found in Nigeria

Legumes	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/ (Ca+Mg)	Authors
Groundnut (*Arachis hypogeal*)	42.00	3.98	2.28	705.11	10.55	6.97	-	3.20	-	0.33	0.06	112.64	Atasie *et al.*,2009
	4.79	3.56	0.71	4.35	-	0.34	0.59	1.96	1.11	-	1.10	1.02	Oluyemi *et al.*, 2005
	0.007	-	0.003	0.010	-	0.217	-	0.132	0.006	-	0.70	-	Ebirien *et al.*, 2011
	-	350.00	76.00	135.80	106.52	3.10	1.90	5.00	1.50	0.71	-	0.32	Badau *et al.*, 2013
Soya bean (*Glycine max*)	-	17.30	17.50	-	1193.30	9.30	1.10	8.40	0.06	0.02	-	-	Odumodu, 2010
	9.60	7.42	8.45	9.45	-	1.11	0.86	4.07	2.52	-	1.02	0.60	Oluyemi *et al.*, 2005
	10.00	320.00	260.00	192.00	750.00	7.00	ND	ND	ND	0.35	0.05	0.33	Ikechukwu and Madu, 2010
Scarlet runner bean (*Phaseolus coccineus*)	0.0084	0.0644	0.0595	0.0377	0.0950	0.0103	0.0003	0.0074	0.0010	0.63	0.22	0.30	Aremu *et al.*, 2006b
	0,0099	0.0665	0.0605	0.0367	0.0831	0.0115	0.0001	0.0083	0.0016	0.73	0.27	0.29	Aremu *et al.*, 2006b
Pigeon pea (*Cajanus cajan*)	220.00	155.00	65.00	141.00	5500.00	36.00	56.00	154.00	ND	0.012	1.56	0.64	Arawande and Borokini, 2010
Kersting's groundnut (*Kerstingiella geocarpa*)	13.40	62.40	66.50	43.50	34.00	5.50	0.20	6.50	1.30	1.96	0.31	0.34	Aremu *et al.*, 2006a
Red kidney bean (*Phaseolus vulgaris* L.)	33.00	820.90	54.90	14.50	3.70	11.50	0.70	2.70	1.70	15.00	2.30	0.02	Audu and Aremu, 2011
Liman bean (*Phaseolus lunatus*)	182.40	111.50	95.30	817.40	ND	3.20	1.03	3.29	3.26	-	0.22	3.95	Ikechukwu and Madu, 2010
Mesquite bean (*Prosopis africana*)	110.70	1420.10	362.50	617.50	196.40	15.50	46.20	22.40	36.20	3.76	0.18	0.35	Aremu *et al.*, 2007a
Pinto bean (*Phaseolus vulgaris* L.)	22.00	789.70	62.90	8.30	4.20	13.30	1.00	3.80	2.90	15.00	2.70	–	Audu and Aremu, 2011b

Black turtle bean (*Phaseolus vulgaris* L.)	24.60	600.10	49.10	14.10	2.40	10.50	0.30	1.40	0.90	20.50	1.80	–	Audu *et al.*, 2013

ND = Not detected; **–** = not available

Tables 2a&b present the mineral content of some fruits/vegetables/nuts which are eaten as complements. Potassium is found to be the most abundant with a level as high as 39856.00 mg/100g in banana (*Musa spp*) and as low as 0.63 mg/100g in guava (*Psidium guajava*). Pawpaw (*Carica papaya*) has the highest content of calcium and magnesium followed by orange (Citrus sinensis), guava (*Psidium guajava*), pineapple (*Ananuscomosus*) and apple (*Malaudomistica*), while bitter leaf (*Veronia amygdalina* L.) has the least content of calcium and magnesium. Apple (*Malaudomistica*) has the highest amount of iron and zinc, followed by guava (*Psidium guajava*) and orange (*Citrus sinensis*) and the other samples contain relatively minute quantities for iron and zinc. Cashew nut (*Anarcardium occidentale*) contains the highest amount of sodium ranged between 0.015 to 280.00 mg/100g.

Sodium is the principal cation in extracellular fluids. It regulate plasma volume and acid – base balance, involved in the maintenance of osmotic pressure of the body fluids, preserves normal irritability of muscle function and involved in Na^+/K^+ - ATPase, maintenance of membrane potentials, transmission of nerve impulses and the absorptive processes of monosaccharide, amino acids, pyrimidines and bile salts. The changes in osmotic pressure are largely dependent on sodium concentration (Malhotra, 1998, Murray *et al.,* 2000, Hays and Swenson, 1985). Potassium is vital in intracellular fluids and functions in acid – base balance, regulation of osmotic pressure, conduction of nerve impulse, muscle contraction particularly the cardiac muscle, cell membrane function and Na^+/K^+ - ATPase. It is also required during glycogenesis, and helps in the transfer of phosphate from ATP to pyruvic acidand probably has a role in many other basic cellular enzymatic reaction (Seotan *et al.,* 2010).

Table 2a: Mineral Composition (mg/100g) of some fruits/vegetables/nuts found in Nigeria

Fruits/Vegetable/Nuts	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/(Ca+Mg)	Authors
Banana (*Musa spp*)	24.30	-	19.20	78.10	-	0.61	-	-	76.20	-	0.31	-	Anhwange *et al.*, 2009
	-	4571.00	724.00	38005.00	-	86.00	-	45.00	-	-	-	-	Ozioma *et al.*, 2013
	0.80	0.35	0.47	0.85	-	0.29	0.01	0.07	0.01	-	0.94	1.04	Oluyemi *et al.*, 2005
	280.00	18.00	135.00	40.00	151.67	14.00	-	-	-	0.89	7.00	0.26	Adolu and Enesi, 2013
	-	5.00	1.60	39856.00	-	52.00	-	48.00	-	-	-	6038.79	Onibon *et al.*, 2007
	-	45.50	-	-	-	1.09	0.16	1.11	-	-	-	-	Falade *et al.*, 2005
	0.86	10.20	5.38	8.76	59.43	1.05	0.12	6.23	-	0.09	0.10	0.56	Makanjoula *et al.*, 2013
	1.24	5.05	4.57	7.14	35.61	1.21	0.11	3.75	-	0.13	0.17	0,74	Makanjoula *et al.*, 2013
	3.10	3.56	3.87	6.55	47.37	0.97	0.07	4.82	-	0.08	0.47	0.88	Makanjuola *et al.*, 2013
Guava (*Psidium guajava*)	0.64	0.44	0.33	0.63	-	0.14	0.07	0.10	0.001	-	1.02	0.82	Oluyemi *et al.*, 2005
	-	1329.00	1456.00	8666.00	-	28.00	-	2209.00	-	-	-	3.11	Onibon *et al.*, 2007
	-	1567.00	1646.00	16618.00	-	240.00	-	6.00	-	-	-	5.7	Ozioma *et al.*, 2013
	0.019	0.018	-	3.950	-	0.001	-	0.001	-	-	0.005	-	Udeme *et al.*, 2013
	0.032	0.006	-	3.510	-	0.001	-	0.002	-	-	0.009	-	Udeme *et al.*, 2013
Pawpaw (*Carica papaya*)	-	4404.00	8490.00	35837.00	-	46.00	-	24.00	-	-	-	2.78	Ozioma *et al.*, 2013
	0.67	0.31	0.43	0.76	-	0.09	0.13	0.25	0.002	-	0.88	1.03	Oluyemi *et al.*, 2005
	-	2824.00	2964.00	4454.00	-	19.00	-	1.00	-	-	-	0.77	Onibon *et al.*, 2007
	0.022	0.011	-	1.13	-	0.0023	-	0.002	-	-	0.02	-	Udeme *et al.*, 2013
	0.028	0.006	-	1.86	-	0.0006	-	0.003	-	-	0.02	-	Udeme *et al.*, 2013
Orange (*Citrus sinensis*)	-	18.00	-	-	-	1.21	0.07	0.96	-	-	-	-	Falade *et al.*, 2005
	-	2010.00	3335.00	12636.00	-	119.00	-	35.00	-	-	-	2.36	Ozioma *et al.*, 2013
	-	85.00	93.00	2712.00	-	240.00	-	10.00	-	-	-	15.23	Onibon *et al.*, 2007
	0.021	0.043	-	2.89	-	0.0005	-	0.002	-	-	0.007	-	Udeme *et al.*, 2013
	0.015	0.010	-	3.15	-	0.001	-	0.002	-	-	0.005	-	Udeme *et al.*, 2013
Pineapple	-	2520.00	1645.00	26103.00	-	328.00	-	15.00	-	-	-	6.27	Ozioma *et al.*, 2013
(*Ananuscomosus*)	-	39.80	-	-	-	1.20	0.12	0.27	-	-	-	-	Falade *et al.*, 2005
	0.019	0.101	-	1.98	-	0.0007	-	0.0001	-	-	0.01	-	Udeme *et al.*, 2013
	0.022	0.060	-	1.00	-	0.0064	-	0.002	-	-	0.02	-	Udeme *et al.*, 2013
Apple (*Malaudomistica*)	-	2712.00	1865.00	28010.00	-	43.00	-	51.00	-	-	-	6.12	Ozioma *et al.*, 2013
	-	16.00	88.00	11440.00	-	1304.00	-	256.00	-	-	-	110.00	Onibon *et al.*, 2007
Cashew nut	22.80	36.40	21.90	38.20	18.60	0.80	0.40	0.80	1.60	1.18	0.60	0.66	Aremu *et al.*, 2007b
(*Anarcardium occidentale*)	8.20	19.30	21.50	27.50	14.00	0.60	-	0.80	-	1.54	0.30	0.67	Akinhanmi *et al.*, 2008
	197.62	170.41	188.78	132.31	68.54	13.27	ND	1.70	1.02	2.75	1.50	0.37	Aletor *et al.*, 2007
	257.71	180.58	220.87	250.49	87.86	17.00	ND	53.40	0.97	2.51	1.03	0.62	Aletor *et al.*, 2007

ND = Not detected; **–** = not available

Table 2b: Mineral Composition (mg/100g) of some fruits/vegetables/nuts found in Nigeria

Fruits/Vegetable/Nuts	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/ (Ca+Mg)	Authors
Bitter leaf (*Veronia amygdalina* L.)	2.77	6.38	20.04	13.37	-	12.69	-	1.32	-	-	0.21	0.51	Omale and Ugwu, 2011
	25.52	-	300.11	43.34	444.60	4.28	0.41	3.97	-	0.68	0.59	-	Ibanga and Okon, 2009
	35.44	-	320.55	26.67	367.41	6.41	0.37	3.24	-	0.87	1.33	-	Ibanga and Okon, 2009
	29.81	24.03	0.50	19.52	3.54	ND	0.62	0.81	0.39	0.14	1.53	0.80	Ajayi and Adesanwo, 2009
	375.69	0.51	0.22	1.18	ND	1.53	6.37	0.86	8.97	-	318.38	1.62	Onuegbu *et al.*, 2011
African pear (*Dacryodes edulis*)	16.02	27.58	34.01	43.42	59.36	4.28	0.04	3.16	-	0.57	0.37	0.70	Amadi *et al.*, 2012
	16.87	27.02	33.85	43.92	58.91	4.19	0.05	3.60	-	0.57	0.38	0.72	Amadi *et al.*, 2012
	16.94	28.02	35.01	43.68	51.12	4.20	0.04	3,01	-	0.68	0.38	0.69	Amadi *et al.*, 2012
	-	286.20	350.00	550.70	695.50	-	-	-	-	0.50	-	0.87	Ngozi-Olehi, 2012
	0.87	0.32	0.13	1.66	10.34	0.80	-	0.31	-	0.01	0.52	3.69	Isiuku *et al.*, 2008
Okra (*Ablenioschus esculentus*)	88.00	83.60	170.60	108.50	9.50	3.60	30.90	18.80	22.70	18.60	0.80	0.43	Aremu *et al.*, 2014
Bush mango (*Irvingia gabonensis*)	113.50	171.10	431.50	161.00	44.50	19.70	47.30	4.90	33.50	9.70	0.70	0.26	Aremu *et al.*, 2014

ND = Not detected; **–** = not available

Roots and tubers (Table 3) are consumed as main staple foods. They have lower concentration of mineral elements when compared with legumes (Table 1a&b). They are mainly sources of carbohydrate in the body and usually with lower protein content. To avoid malnutrition, they should be taken along with some complements such as melon, fruits and vegetable that contain higher mineral contents. Among the cereals (Table 4), millet (*Pennisetum typhoides*), guinea corn (*Sorghum bicolor*) and maize (*Zea mays*) have the highest mineral content. In fact, they are commonly used as weaning food for babies (Asubiojo and Iskander, 1988; Aremu *et al.* 2011).

Magnesium is an active component of several enzyme systems in which thymine pyrophosphate is a cofactor. Oxidative phosphorylation is greatly reduced in the absence of magnesium. It activates pyruvic acid carboxylase, pyruvic acid oxidase, and the condensing enzyme for the reaction in the citric acid cycle. It is also a constituent of bones, teeth, enzyme cofactor, etc (Murray *et al.,* 2000). Copper is an essential micro- nutrient necessary for the hoematologic and neurologic system (Tan *et al.,* 2006). It is necessary for the growth and formation of bone, formation of myelin sheaths in the nervous systems, helps in the incorporation of iron in haemoglobin, assists in the absorption of iron from the gastrointestinal tract (GIT) and in the transfer of iron from tissues to the plasma (Malhotra, 1998; Murray *et al*., 2000). Iron is an important constituent of succinate dehydrogenase as well as a part of the haeme of haemolobin (Hb), myoglobin and the cytocromes. It is requires for proper myelination of spinal cord and white matter of cerebellar folds in brain and is a cofactor for a number of enzymes involved in neurotransmitter synthesis. It is also involved in synthesis and packaging of neurotransmitters, their uptake and degradation into other iron- containing proteins which may directly or indirectly alter brain function (Larkin and Rao, 1990, Beard, 2001). Zinc functions as a cofactor and is a constituent of many enzymes like lactate dehydrogenase, DNA and RNA polymerase. Zinc dependent enzymes are involved in macronutrient metabolism and cell replication (Arinola, 2008)[85]. Manganese is a part of enzymes involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis (Chadra, 1990).

Table 3: Mineral Composition (mg/100g) of some roots & tubers found in Nigeria

Roots & Tubers	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/ (Ca+Mg)	Authors
Yam	5.40	9.47	28.06	145.33	43.82	-	-	0.26	0.032	0.64	0.037	3.87	Afiukwa *et al.*, 2013
(*Dioscorea spp*)	3.30	7.33	56.11	104.00	45.00	-	-	0.25	0.024	1.25	0.032	1.64	Afiukwa *et al.*, 2013
	0.18	0.49	1.80	0.50	0.28	-	-	-	-	6.43	0.36	0.22	Okwu and Ndu, 2006
	0.19	0.73	1.60	0.75	0.29	-	-	-	-	5.52	0.25	0.32	Okwu and Ndu, 2006
	0.22	0.85	1.80	1.00	0.36	-	-	-	-	5.00	0.22	0.38	Okwu and Ndu, 2006
	185.15	45.90	132.02	209.13	54.00	81.85	10.06	5.46	-	2.44	0.89	1.18	Alinnor and Akalezi, 2010
	1.40	0.73	1.06	1.37	-	0.64	0.07	0.26	0.005	-	1.02	0.77	Oluyemi *et al.*, 2005
Cassava	52.00	24.00	290.00	140.00	60.00	10.00	-	340.00	-	4.83	0.37	0.45	Ayodeji, 2005
(*Manihot esculanta*)	69.00	21.00	220.00	140.00	50.00	11.30	-	260.00	-	4.40	0.49	0.58	Ayodeji, 2005
	76.00	11.00	120.00	200.00	70.00	10.20	-	220.00	--	1.71	0.38	1.53	Ayodeji, 2005
	65.00	48.00	200.00	150.00	60.00	10.50	-	210.00	-	3.33	0.43	0.60	Ayodeji, 2005
	6.37	80.00	80.00	290.00	120.00	16.35	0.63	0.80	2.81	0.67	0.022	1.81	Adeniji *et al.*, 2007
	5.03	70.00	70.00	390.00	100.00	18.40	0.46	0.60	2.82	0.70	0.013	2.79	Adeniji *et al.*, 2007
	4.69	90.00	70.00	350.00	100.00	11.73	1.09	0.85	2.45	0.70	0.013	2.19	Adeniji *et al.*, 2007
	1.10	0.61	1.05	1.48	-	0.53	0.034	0.082	0.05	-	0.74	0.89	Oluyemi *et al.*, 2005
Cocoyam (*Xanthosoma*	270.83	28.02	87.14	345.32	36.00	59.07	6.72	1.30	-	2.42	0.78	3.00	Alinnor and Akalezi, 2010
sagititolium)	1365.05	313.70	190.93	3057.16	44.39	8.28	0.52	2.49	ND	4.30	0.45	6.06	Njoku and Ohia, 2007
	1297.89	314.30	107.38	1737.48	44.94	9.11	0.78	3.10	ND	2.39	0.75	4.12	Njoku and Ohia, 2007
	1521.34	415.07	132.43	4276.04	72.21	8.66	1.04	2.63	0.13	1.83	0.36	7.81	Njoku and Ohia, 2007
	277.60	-	51.70	1113.80	59.83	0.70	-	0.40	-	0.86	0.25	-	Olayiwola *et al.*, 2013
	434.00	-	54.43	1125.50	63.40	0.91	-	0.44	-	0.86	0.39	-	Olayiwola *et al.*, 2013
	260.00	-	56.30	1045.30	59.83	0.77	-	0.37	-	0.94	0.25	-	Olayiwola *et al.*, 2013
Sweet potatoes	4.23	340.00	28.44	4.50	37.28	16.00	0.00	0.08	4.64	0.76	0.94	0.01	Antia *et al.*, 2006
(*Ipomoea batatas* L.)	-	-	27.99	-	-	8.82	-	0.09	-	-	-	-	Olayiwola *et al.*, 2009
	-	-	20.33	-	-	1.61	-	0.12	-	-	-	-	Olayiwola *et al.*, 2009
	28.00	30.40	90.40	115.00	20.00	-	-	-	-	4.52	0.24	0.95	Ukom *et al.*, 2009
	28.00	12.20	70.30	173.00	27.50	-	-	-	-	2.56	0.16	2.10	Ukom *et al.*, 2009
	33.29	12.20	50.20	203.00	20.10	-	-	-	-	2.50	0.16	3.25	Ukom *et al.*, 2009
	23.00	18.20	40.20	158.00	25.00	-	-	-	-	1.61	0.15	2.71	Ukom *et al.*, 2009

ND = Not detected; – = Not available

Table 4: Mineral Composition (mg/100g) of some cereals found in Nigeria

Cereals	Na	Mg	Ca	K	P	Fe	Cu	Zn	Mn	Ca/P	Na/K	K/(Ca+Mg)	Authors
Maize (*Zea mays*)	0.006	-	0.005	0.011	-	0.232	-	0.084	0.007	-	0.06	-	Ebirien *et al.*, 2011
	-	27.45	-	0.48	-	4.30	0.60	-	-	-	-	-	Maloma *et al.*, 2013
	-	25.13	-	0.50	-	5.95	1.07	-	-	-	-	-	Maloma *et al.*, 2013
	-	32.10	-	0.42	-	3.60	0.83	-	-	-	-	-	Maloma *et al.*, 2013
	-	24.80	-	1.02	-	4.62	0.55	-	-	-	-	-	Maloma *et al.*, 2013
	-	25.82	-	0.40	-	3.25	0.25	-	-	-	-	-	Maloma *et al.*, 2013
	-	26.95	-	0.38	-	5.00	0.20	-	-	-	-	-	Maloma *et al.*, 2013
	-	24.83	-	0.12	-	5.45	0.45	-	-	-	-	-	Maloma *et al.*, 2013
	-	25.46	-	0.42	-	2.85	0.50	-	-	-	-	-	Maloma *et al.*, 2013
	2.91	1.74	0.05	2.92	-	0.23	0.26	1.67	0.70	-	0.99	1.63	Falade *et al.*, 2005
	63.70	310.70	188.70	301.30	230.00	7.20	0.60	16.70	3.30	0.82	0.21	6.03	Aremu *et al.*, 2005a
	520.00	120.00	2.00	510.00	280.00	2.00	0.38	5.00	0.16	0.007	1.02	4.18	Aremu *et al.*, 2005b
	-	-	-	-	-	4.80	0.40	3.00	0.20	-	-	-	Aremu *et al.*, 2006d
	-	78.00	1.10	328.00	231.00	2.40	0.29	1.80	0.48	0.005	-	4.15	Badau *et al.*, 2013
Guinea corn	187.70	348.30	226.70	245.70	124.00	2.15	0.60	13.70	0.35	1.83	0.76	0.43	Aremu *et al.*, 2005a
(*Sorghum bicolor*)	4.89	3.04	0.55	4.82	-	0.84	0.37	2.43	1.56	-	1.01	1.34	Oluyemi *et al.*, 2005
	-	-	-	-	-	3.10	1.00	4.90	1.00	-	-	-	Aremu *et al.*, 2006d
Millet	4.85	2.97	0.75	4.60	-	0.75	0.43	2.50	1.02	-	1.05	1.24	Oluyemi *et al.*, 2005
(*Pennisetum typhoides*)	15.10	183.00	299.00	618.00	325.00	8.23	0.77	2.93	23.30	0.92	0.02	1.28	Robert *et al.*, 2008
	15.10	173.00	371.00	571.00	279.00	26.00	0.79	2.68	39.20	1.33	0.03	1.05	Robert *et al.*, 2008
	14.30	167.00	532.00	432.00	223.00	20.30	0.68	2.53	25.00	2.39	0.03	0.62	Robert *et al.*, 2008
Rice (*Uryza sativa*)	3.24	1.54	0.07	3.20	-	0.43	0.78	1.23	0.51	-	1.01	1.99	Oluyemi *et al.*, 2005
	-	67.00	80.00	-	73.00	46.30	-	-	-	1.10	-	-	Osaretin and Abosede, 2007
	-	82.00	80.00	-	94.00	42.90	-	-	-	0.85	-	-	Osaretin and Abosede, 2007

ND = Not detected; – = Not available

Modern diets that are rich in animal proteins and phosphorus may promote the loss of calcium in the urine (Arrinola, 2008). This has led to the concept of the Ca/P ratio. If the Ca/P ratio is low (low calcium, high phosphorus intake) more than the normal amount of calcium may be loose in the urine thereby decreasing the calcium level in bones. Food is considered 'good' if the Ca/P ratio is above 1 and 'poor' if the ratio is less than 0.5, while the Ca/P ratio above 2 helps to increase the absorption of calcium in the small intestine (Aremu *et al.*, 2013, Nieman *et al.*, 1992). Ca/P ratio of roots and tubers, and legumes reviewed are generally greater than 0.5, indicating that they would serve as good sources of mineral for bone formation. The sodium to potassium ratio of less than 1 is recommended for the prevention of high blood pressure (Nieman *et al.*, 1992). Hence, most of the legumes, roots and tubers, and fruits samples reviewed would probably reduce high blood pressure disease because they had Na/K ratio of less than one. In order to prevent a disease known as hypomagnesaemia, the milliequivalent of [K/(Ca+Mg)] in food sample must be less than 2.2 (Marten and Anderson, 1975). Therefore, most of the legumes, fruits and cereals samples reviewed may not lead to hypomagnesaemia.

5. Conclusion

In view of the importance of these macro and micro minerals in the nutrition of human being and their metabolic inter-relationships which influence other vital factors needed for the survival of living organisms like enzymes, anti-oxidants, vitamins etc, it is important to regularly obtain up-to-date information on the mineral contents of variously commonly consumed plant foods used for human foods e.g. legumes, cereals, fruits and vegetables. This is because of the effects of chemicals like pesticides, herbicides, fertilizers on the mineral contents of the soils where these plants are cultivated. Genetic, location and environmental factors could also influence the levels of the mineral elements in plants.

6. References

Abiodun, A. O. and Adepeju, A. B. (2011). Effect of processing on the chemical, pasting and anti-nutritional composition of bambara Nut (*Vigna subterranea* L. Verdc) flour. Advance Journal of Food Science and Technology, 3(4): 224-227.

Adeniji, T.A., Sanni, L.O., Barimalaa, I.S. and Hart, A.D. (2007). Mineral composition of five improved varieties of Cassava. Nigerian Food Journal, 25(2): 39 – 44.

Adeolu A.T. and Enesi, D.O. (2013). Assessment of proximate, mineral, vitamin and phytochemical compositions of plantain *(Musa paradisiaca)* bract – an Agricultural waste. International Research Journal of Plant Science, 4(7): 192-197.

Adewusi, S.R.A., Ojuma, T.V. and Falade, S.O. (1999). The effects of processing on total organic acids content and mineral availability of simulated cassava-vegetable diets. Plant Foods for Human Nutrition, 53: 380 – 386.

Afiukwa, C.A., Ogah, O., Ugwu, O.P. C., Oguguo, J.O., Ali, F.U. and Ossai, E.C. (2013). Nutritional and Antinutritional characterization of two wild Yam species from Abakaliki, Southeast Nigeria. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 4(2): 840 – 848.

Ajayi, I.A. and Adesanwo, O. (2009). Comparative Study of the Mineral Element and Fatty Acid Composition of *Dacryodes edulis* Pulp and Seed. World Journal of Agricultural Sciences, 5(3): 279-283.

Akinhanmi, T.F., Atasie, V.N. and Akintokun, P.O. (2008). Chemical composition and physicochemical properties of Cashew nut *(Anacardium occidentale)* oil and Cashew nut shell liquid. Journal of Agric Food & Environment Science, 2(1): 1 – 10.

Akpambang, V.O.E., Amoo, I.A., Andizuagie, A.A. (2008). Comparative Compositional Analysis on two varieties of Melon *(Colocynthis citrullus* and *Cucumero psisedulis)* and a variety of Almond (*Prunusamygdalus*). Research Journal of Agriculture and Biological Sciences, 4(6): 639-642.

Albion Research Notes (1996). A compilation of vital research updates on human nutrition, 5: 2, Albion laboratories, Inc. May, 1996.

Aletor, O., Agbede, J.O., Adeyeye, S.A. and Aletor, V.A. (2007). Chemical and physio-chemical characterization of the flours and oils from whole and rejected Cashew nuts cultivated in Southwest Nigeria. Pakistan Journal of Nutrition, 6(1): 89-93.

Aletor, V.A. and Omodara, O.A. (1994). Studies on some leguminous browse plants, with particular reference to their proximate, mineral and some endogenous anti-nutritional constituents. Animal Feed Science Technology, 46: 343-348.

Alinnor, I.J. and Akalezi, C.O. (2010). Proximate and mineral compositions of *Dioscorea rotundata* (White Yam) and *Colocasia esculenta* (White Cocoyam). Pakistan Journal of Nutrition, 9(10): 998-1001.

Amadi, B.A., Arukwe, U., Duru, M.K.C., Amadi, C.T., Adindu, E.A., Egejuru, L., and Odika, P.C. (2012). Phytonutrients and antinutrients screening of *D. edulis* fruits at different maturation stages. Journal of Natural Product Plant Resource, 2(2): 310-313.

Anhwange, B.A., Ugye, T.J. and Nyiaatagher, T.D. (2009). Chemical composition of *Musa sapientum* (Banana) peels. EJEAFCHE, 8(6): 437- 442.

Antia, B.S., Akpan, E.J., Okon, P.A. and Umoren, I.U. (2006). Nutritive and Anti-Nutritive evaluation of Sweet Potatoes *(Ipomoea batatas*) leaves. Pakistan Journal of Nutrition, 5(2): 166-168.

Arawande, J.O. and Borokini, F.B. (2010). Comparative study on chemical composition and functional properties of three Nigerian legumes (jack beans, pigeon pea and cowpea). JETEAS, 1(1): 89 – 95.

Aremu, M.O., Opaluwa, O.D., Bamidele, T.O., Nweze, C.C., Ohale, I.M. and Ochege, M.O. (2014). Comparative evaluation of nutritive value of okro (*Abelmoschus esculentus*) and bush mango (*Irvingia gabonensis*) fruits grown in Nasarawa State, Nigeria. Food Science and Quality Management, 27: 63 – 70.

Aremu, M.O., Namo, S.B., Salau, R.B., Agbo, C.O. and Ibrahim, H. (2013). Smoking methods and their effects on nutritional value of african catfish (*Clarias gariepinus*). The Open Nutraceuticals Journal, 6: 1 – 8.

Aremu, M.O., Ogunlade, I. and Olonisakin, A. (2007b). Fatty acid and amino acid composition of protein concentrate from cashew nut (*Anarcadium occidentale*) grown in Nasarawa State, Nigeria. Pakistan Journal of Nutrition, 6(5): 419-423.

Aremu, M.O., Olaofe, O. and Akintayo, E.T. (2006c). Chemical composition and physiochemical characteristics of two varieties of bambara groundnut (*Vigna subterrenea*) flours. Journal of Applied Science, 6(9): 1900 -1903.

Aremu, M.O., Olaofe, O. and Akintayo, T.E. (2006a). A comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. Pakistan Journal of Nutrition, 5(1): 34-38.

Aremu, M.O., Olaofe, O. and Olanisakin, A. (2005b). Nutritional valuable mineral contents of two varieties of Maize *(Zea mays)* produced in Ilorin, Kwara State, Nigeria. Journal of Ultra Chemistry, 1(2), 87 – 90.

Aremu, M.O., Olaofe, O., and Akintayo, T.E. (2006b). Compositional evaluation of cowpea *(Vigna unguiculata)* and scarlet runner bean *(Phaseolus coccineus)* varieties grown in Nigeria. Journal of Food, Agriculture & Environment, 4(2): 39-43.

Aremu, M.O., Osinfade, B.G., Basu, S.K. and Ablaku, B.E. (2011). Development and nutritional quality evaluation of kersting groundnut for African weaning diet. American Journal of Food Technology, 6(12): 1021–1033.

Aremu, M.O., Olaofe, O., Basu, S.K., Abdulazeez, G. and Acharya, S.N. (2010). Processed cranberry bean (*Phaseolus coccineus* L.) seed flour for the African diet. Canadian Journal of Plant Science, 90: 719 – 728.

Aremu, M.O., Olonisakin, A. and Ahmed, S.A. (2006d). Assessment of heavy metal content in some selected agricultural products planted along some roads in Nasarawa State, Nigeria. Journal of Engineering Applied Science, 1(3): 199 - 204.

Aremu, M.O., Olayioye, Y.E. and Ikokoh, P.P.(2009). Effect of processing on nutritional quality of kersting groundnut (*Kerstingiella geocarpa L)* seed flours. Journal of Chemical Society of Nigeria, 34(2): 140–149.

Aremu, M.O., Olonisakin, A., Atolaiye, B.O. and Ogbu, C. F. (2007a). Some nutritional composition and functional properties of *Prosopis africana*. Bangladesh Journal of Science Industrial Research, 42(3): 269-280.

Aremu, M.O., Olonisakin, A., Otene, I.W. and Atolaiye, B.O. (2005a). Mineral content of some agricultural products grown in the middle belt of Nigeria. Oriental Journal of Chemistry, 21(3): 419 – 425.

Arinola, O.G. (2008). Essential trace elements and metal binding proteins in Nigerian consumers of alcoholic beverages. Pakistan Journal of Nutrition, 7(6): 763-765.

Asubiojo, O.I. and Iskander, F.Y. (1988). A trace element study of commercial infant milk and cereal formular's. Journal of Radioanalytical Nuclear Chemistry, 125(2): 265 – 270.

Atasie, V.N., Akinhanmi, T.F. and Ojiodu, C.C. (2009). Proximate analysis and physioco-chemical properties of Groundnut *(Arachis hypogaea L.).* Pakistan Journal of Nutrition, 8(2): 194 – 197.

Audu, S.S. and Aremu. M.O (2011a). Effect of processing on chemical composition of Red kidney bean (*Phaseolus vulgaris l.*) Flour. Pakistan Journal of Nutrition, 10(11): 1069 – 1075.

Audu, S.S. and Aremu, M.O. (2011b). Nutritional composition of raw and processed pinto bean (*Phaseoulus vulgaris* L.) grown in Nigeria. Journal of Food Agriculture & Environment,9(3&4): 72–80.

Audu, S.S., Aremu, M.O. and Lajide, L.(2013). Influence of traditional processing on the nutritional composition of black turtle bean (*Phaseolus vulgaris* L.) grown in Nigeria. International Food Research Journal, 20: 3211– 3220.

Ayodeji, O.F. (2005). Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*) Antinutrients. Pakistan Journal of Nutrition, 4(1): 37-42.

Badau, M.H., Abba, H.Z., Agbara, G.I. and Yusuf, A.A. (2013). Proximate composition, mineral content and acceptability of granulated maize dumpling (*Dambumasara*) with varying proportions of ingredients. Global Advanced Research Journal of Agricultural Science, 2(1): 007-016.

Batra, J. and Seth, P.K. (2002). Effect of iron deficiency on developing rat brain. Indian Journal of Clinical Biochemistry 17(2): 108-114.

Beard, J. L. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning, Journal of Nutrition 131: 5685-5695.

Bender, A. (1992). Meat and Product in Human Nutrition in Developing Countries, FAO Food and Nutrition Paper 53. Food and Agriculture Organization, Rome Italy.

Bran, A.F. and Allan, G.C. (1975). Food Science. A Chemical Approach, Hoddle, London, 3, 238.

Chakravarty, I. and Ghosh, K. (2000). Micronutrient malnutrition-present status and future remedy. Journal of Indian Medical Association, 98(9): 539-542.

Chandra, R.K. (1990). Micro-nutrients and immune functions: An overview. Annal. New York Academic Science, 587: 9-16.

Chinma, C.E., Alemede, I.C. and Emelife, I.G. (2008). Physicochemical and functional properties of some Nigerian cowpea varieties. Pakistan Journal of Nutrition, 7(1): 186-190.

Cornelis, K. and Hulbut, C.T. (1985). Manual of Mineralogy 20th ed. Wely, pp. 1 – 10

Crossby, N.T. (1977). Determination of metals in food. The Analyst, 1213: 255 – 256.

Ebirien, P.F., Bassey, O.E. and Ozioma, A.E. (2011). Evaluation of the effects of processing on the mineral contents of maize (*Zea mays*) and groundnut (*Arachis hypogaea*). Libyan Agriculture Research Center Journal International, 2(3): 133-137.

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

Fagbohun, E.D., Lawal, O.U. and Hassan, O.A. (2011). The Chemical Composition and Mycoflora of sundried shelled melon seeds *(citrullus vulgaris)* during storage. International Research Journal of Microbiology (IRJM), 2(8): 310-314.

Falade, S.O., Oladipo, A.O., Abiodun, A.O., Ayo, T. and Steve, A.A. (2005). Dietary fibre and mineral availability in some Nigerian fruit-vegetable and fruit-legume composite diets. Malaysian Journal of Nutrition, 11(1): 33 – 45.

Fleck, H. (1976). Introduction to Nutrition, 3rd edition, Macmillan New York, pp. 207 – 219.

Gorsuch, T.T. (1959). Radiochemical investigations on the recovery for analysis of trace elements in organic and biological materials. Analyst, 84: 135.

Hays, V.W. and Swenson, M.J. (1985). Minerals and bones. In: Dukes' Physiology of Domestic Animals, tenth edition pp. 449-466.

Health and Welfare (1982). Recommended Nutrient Intakes for Canadians. Bureau of Nutritional Sciences, Health Protection Branch, Ottawa, Ontaio.

Hegsted, D.M., Chichester, C.O., Darby, W. J., Mcnutt, K.W., Stalvey, R.M., and Stotz, E.H. (1976). In: Present knowledge in nutrition (nutrition reviews'), fourth edition. The Nutrition Foundation Inc. New York, Washington.

Hendricks, D.G. (2002). Mineral analysis by traditional methods. In: Introduction to the Chemical Analysis of Food. CBS, New Delhi, India, pp. 123 – 130.

Ibanga, O.I. and Okon, D.E. (2009). Minerals and anti-nutrients in two varieties of African pear (*Dacryodes edulis*). Journal of Food Technology, 7(4): 106 – 110.

Ikechukwu, E.E. and Madu, D.I. (2010). Biochemical Composition and Nutritional Potential of Ukpa: A variety of tropical Lima beans (*Phaseolus lunatus*) from Nigeria – a short Report. Polish Journal of Food Nutritional Science, 60(3): 231-235.

Isiuku, B., Nwanjo, H. and Asimole, C. (2008). A comparative study of the lipid protein and mineral contents of African pear (*Dacryodes edulis*) seed and Avocado Pear seeds. The Internet Journal of Nutrition and Wellness, 8(2): 217 – 224.

Jackson, B.A., Adamade, C.A. Azogu, I.I. and Oni, K.C. (2013). Melon pod fermentation and its effects on physiochemical Characteristics of Melon seeds. Academic Journals, 8(17): 664-669.

Larkin, E. C. and Rao, C. A. (1990). Importance of fetal and neonatal iron; adequacy for normal development of central nervous system, In: Brain Behavior and Iron in the Infant diet (Dobbing, J. ed), London, UK, pp. 43-63.

Lawal, O.U. (2011). Effect of storage on the nutrient composition and the mycobiota of sundried water melon seeds (*citrullus lanatus).* Journal of Microbiology, Biotechnology and Food Sciences, 1(3): 267-276.

Makanjuola, O.M., Ajayi, A.B., Mattew, K. and Makanjuola, J.O. (2013). The proximate composition and mineral contents of three Plantain cultivars harvested at matured green level. International Journal of Innovations in Bio-Sciences, 3(2): 23-26.

Malhotra, V.K (1998). Biochemistry for Students. Tenth edition. Jaypee Brothers Medical Publishers (p) Ltd, New Delhi, India.

Malomo, O., Olufade, O.I., Adekoyeni, O.O. and Jimoh, M.O. (2013). Evaluation of heavy metal concentration in Maize grown in selected industrial areas of Ogun State and its effects on urban food security. International Journal of Science, Technology and Society, 1(2): 48-56.

Marten, C.R. and Anderson, A.B. (1975). Practical Food Inspection. Ninth edition. Itaze II Watson and Viney Ltd. Alesbury, 1975; p. 232.

Micheal, A.G. (2002). Enhancing mineral content in plant food products. Journal of American coll. Nutrition, 21(3): 1785 – 1805.

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

Ngozi-olehi, L.C. (2012). Comparative analysis of the nutritional contents of Avocado Pear *(Persea americana)* and African pear *(Dacryodes edulis).* Journal of Educational and Social Research, 2(8): 169 – 173.

Nieman, D.C., Butter Worth, D.E. and Nieman, C.N. (1992). Nutrition's. W.M.C. Brown Publisher Dubugue pp. 9 – 54.

Njoku, P.C. and Ohia, C.C. (2007). Spectrophometric estimation studies of mineral nutrient in three Cocoyam cultivars. Pakistan Journal of Nutrition, 6(6): 616-619.

Odumodu, C.U. (2010). Nutrients and Anti-nutrients content of dehulled Soybean. Continental Journal of Food Science and Technology, 4: 38 – 45.

Ojieh, G.C., Oluba, O.M., Ogunlowo, Y.R., Adebisi, K.E., Eidangbe, G.O. and Orole, R.T. (2008). Compositional studies of *Citrullus lanatus* (Egusi melon) seed. The Internet Journal of Nutrition and Wellness, 6(1): 115 – 126.

Okwu, D.E. and Ndu, C.U. (2006). Evaluation of the phytonutrients, mineral and contents of some varieties of yam (*Dioscorea sp.*). International Journal of Molecular Medicine and Advance Sciences, 2(2): 199 – 203.

Olayiwola, I.O., Abubakar, H.N., Adebayo, G.B. and Oladipo, F.O. (2009). Study of Sweet Potato (*Ipomea batatas*) foods for indigenous consumption through chemical and anti-nutritive analysis in Kwara State, Nigeria. Pakistan Journal of Nutrition, 8(12): 1894-1897.

Olayiwola, I., Funmi, F., Abdul-Rasaq, A.A., Onabanjo, O., Sanni, A. and Afolabi, W. (2013). Chemical, mineral composition and sensory acceptability of cocoyam-based recipes enriched with cowpea flour. Food Science & Nutrition, 1(3): 228 – 234.

Oluyemi, E.A., Akinlua, A.A., Adenuga, A.A. and Odebajo, M.B. (2005). Mineral contents of some commonly consumed Nigerian foods. European J. of Scientific Research, 6(2): 11 – 15.

Omale, J. and Ugwu, C.E. (2011). Comparative studies on the protein and mineral composition of some selected Nigerian vegetables. African Journal of Food Science, 5(1): 22 – 25.

Onibon, V.O., Abulude, F.O. and Lawal, L.O. (2007). Nutritional and anti-nutritional composition of some Nigerian fruits. *J. of Food Technology*, 5(2): 120 – 122.

Audu, S.S. and Aremu, M.O. (2011b). nutritional composition of raw and processed pinto bean (*Phaseolus vulgaris* L.) grown in Nigeria. Journal of Food, Agriculture & Environment, 9(3&4): 72 – 80.

Onuegbu, N.C., Adedokun, I.I., Kabuo, N.O. and Nwosu, J.N. (2011). Amino acid profile and micronutrient composition of the African Pear (*Dacryodes edulis*) pulp. Pakistan Journal of Nutrition, 10 (6): 555-557

Osaretin, A.T.E. and Abosede, C.O. (2007). Effect of cooking and soaking on physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign rice varieties in Nigeria. African Journal of Biotechnology, 6(8): 1016-1020.

Owolabi, A.O., Ndidi, U.S., James, B.D. and Amune, F.A. (2012). Proximate, Antinutrient and mineral composition of five varieties (improved and local) of Cowpea, *Vigna unguiculata*, commonly consumed in Samaru community, Zaria-Nigeria. Asian Journal of Food Science and Technology, 4(2): 70-72

Ozcan, M. (2003). Mineral contents of some plants used as condiments in Turkey. Food chemistry 84: 437-440.

Ozioma, A.E., Onisogen, S.E. and Ebirien, P F. (2013). Proximate and mineral composition of some Nigerian fruits. British Journal of Applied Science & Technology, 3(4):1 – 8.

Pike, R.I. and Brown, M.L. (1967). Nutrition; An Inegrated Approach. Wiley, New York, USA, pp. 92 – 93.

Rao, C.N. and Rao, B.S.N. (1981). Trace element content of Indian foods and the dietaries. Indian Journal of Medical Research, 73: 904-909.

Robert, S.G., Lu-Te, C., Jennifer, L.R. and Robert, H.G. (2008). Amino acid, fatty acid and mineral content of black finger millet (*Eleusine coracana*) cultivated on the Jos Plateau of Nigeria. Food, 2(2): 115 – 118.

Roberts, J.V. (1985). Textbook of Biology, first edition, JB Publishers, India.

Rush, D. (2000). Nutrition and maternal mortality in the developing world. American Journal of Clinical Nutrition, 72(suppl.): 2125-2405.

Sandel, E.B. (1959). Colorimetric determination of traces of metals. 3rd edition, Interscience Publishers Inc., New York p. 460.

Sandstead, H.H. (1975). Some trace elements which are essential for human nutrition; zinc, copper, manganese and chromium. *Prog. Food Nutri. Sci.*, 1: 371 – 391

Shills, M.Y.G. and Young, V.R. (1992). Modern nutrition in health and disease. In: Nutrition, Nieman, D. C., Butterworth, D. E. and Nieman, C. N. (eds), WMC Brown Publishers, Dubuque IA 1992; pp. 176-282.

Shils, M. E. (1973). Magnesium. In: *Introduction to Nutrition*, H. Fleck (ed) (1976), 3rd edition, Macmillan New York, pp. 255.

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

Tan, J.C., Burns, D.L. and Jones, H.R. (2006). Severe ataxia, myelopathy and peripheral neuropathy due to acquired copper deficiency in a patient with history of gastrectomy. Journal of Paenteral Nutr 30: 446-450.

Udeme, J.O., Kpobari, W.N., Joyce, O.A., Augustine, A.U. (2013). Proximate, phytochemical and mineral elements compositions of some edible fruits grown in oil producing community of Rivers State, Nigeria. Journal of Environmental Science, Toxicology and Food Technology, 5(2): 38-46.

Ujowundu, C.O., Nwaogu, L.A., Ujowundu, F.N. and Belonwu, D.C. (2013). Effect of gas flaring on the phytochemical and nutritional composition of *Treculia africana* and *Vigna subterranea*. British Biotechnology Journal, 3(3): 293-304.

Ukom, A.N., Ojimelukwe, P.C. and Okpara, D.A. (2009). Nutrient composition of selected sweet potato (*Ipomea batatas*) varieties as influenced by different levels of nitrogen fertilizer application. Pakistan Journal of Nutrition, 8(11): 1791-1795.

Vyas, D. and Changra, R.K. (1984). Iron Nutrition in Infancy and Childhood. Discovery and Innovation, 11: 75 – 81.