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Comparative Evaluation of the Levels of Minerals and Mineral Safety Index of Waw, Roasted and Cooked *Treculia africana* Seed Flours

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Raw, cooked and roasted seed parts of Treculia africana commonly called "afon" in Yoruba and "ukwa" in Ibo languages were investigated for the mineral composition using standard methods. Calculations of Ca/P, Na/K, [K/(Ca+Mg)], Ca/Mg ratios and mineral safety index were also carried out. In the mineral composition, raw samples were best in Na and K; roasted samples were highest in Ca and Mg; cooked samples were highest in Zn, Fe, Mn and P; in all the samples, Ca/P was generally lower than the 0.5 recommended for favourable absorption of calcium in the intestine for bone formation; the samples were all good in Na/K in that they were all lower than 0.6 recommended as the highest limit ratio that prevent high blood pressure; both the raw and processed samples were high in [K/(Ca+Mg)] and non of the sample type was good in Ca/Mg. In the mineral safety index (MSI) values: Fe with standard MSI of 6.7 recorded negative values of -3.20 and -4.20 in roasted seeds testa and cooked testa flours respectively whereas in all other sample parts positive values were recorded. The statistical analysis results (linear correlation) on a pair-wise comparison showed that the mineral contents in raw/roasted and raw/cooked were significantly different at r = 0.05, df=n-1. The research has provided nutritional information with respect to processing methods on minerals in the various parts of the seeds analyzed and that levels of nutritive minerals were more positively enhanced in the roasted seeds flour than in the cooked sample flours.

Keywords: Treculia africana, Mineral, Safety index, Processing method

Introduction

The Food and Agriculture Organization (FAO) of the World Health Organization (WHO) estimated that between 1990 and 1992, 204 million sub-Saharan Africans (41% of the population of the region) were chronically undernourished. The WHO 1995 estimates for iodine, vitamin A and iron deficiencies in Africa show that 181 million Africans were at risk of iodine deficiency, 1 million had xerophthalmia, while 206 million had iron deficiency or anaemia (Latham, 1997). Despite these awful pictures, the population of sub-Saharan Africa is increasing at a very high rate such that food production is not just insufficient to feed the teeming population, but the continued reliance on the regular sources of protein, energy and other nutrients presents a bleak future. It is on this premise that adequate food supply has become a burning issue in the region (FAO, 1985) and research efforts have been geared towards finding (1) alternate sources of protein, energy and other nutrients especially from readily available but hitherto underutilized plants (Giami and Wachukwu, 1997; Enujuigha and Ayodele-Oni, 2003) and (2) better processing methods that ensure longer shelf life of fairly available plant foods. The African breadfruit is one of such plants. The occurrence of elements in foods is a function of the biological roles played by the elements in the structure and physiology of the food tissue, and adventitious contamination during growth, processing, and preparation (Ihnat, 1988). Twenty-six of the naturally occurring elements are known to be essential for life. A wide range of minerals occur in feedstuffs as naturally occurring and purposely added elements, as well as by adventitious contamination. Mineral elements can generally be classified as nutritionally essential major elements, such as Ca, Cl, K, Mg, N, Na, P, and S; nutritionally essential minor and trace elements, such as B, Br, Fe, I, and Si; and those regarded as toxic or with an essential/toxic duality: As, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, Pb, Pd, Se, Sn, Ti, V, and Zn. At excessive levels, even nutritionally essential elements may exhibit toxicity. Some idea of the elemental content to be expected in feedstuffs (with perhaps the exception of premixes and other specialty products) can be surmised

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from a listing of estimated typical ranges of some of the more important elements in 12 classes of foods (similar to feed materials) presented by Ihnat (1988).

African breadfruit (*Treculia africana*) is a traditionally important edible fruit tree in Nigeria (Okafor, 1985) whose importance is due to the potential use of its seeds, leaves, timber, roots and bark. It is increasingly becoming commercially important in Southern Nigeria hence, Baiyeri and Mbah (Baiyeri and Mbah, 2006) described it as an important natural resource which contributes significantly to the income and dietary intake of the poor. The seeds are used for cooking and are highly nutritious as pointed out by various authors (Okafor and Okolo, 1974; Okafor, 1990 and Onyekwelu and Fayose, 2007). The seeds have an excellent polyvalent dietetic value whose biological value exceeds even that of soybeans (2004). The specie provides fodder for animals and the wood is put into various uses including furniture making, pulp and paper production as well as fibre-board production. It also has various medicinal uses including its use as cure for malaria, cough and rheumatism (Irvine, 1981). The seeds of *Treculia africana* are eaten as a delicacy in Nigeria (especially in the South-Eastern parts of the country). As a result of its poor shelf life, most of the harvested seeds are eaten fresh. If a higher utilization of African breadfruit, especially in this period of a shortage in food supply, is to be achieved, then preservation techniques must be employed. This study aims at assessing the effects of the various traditional methods (De-hulling, roasting and cooking) employed in the processing of *Treculia africana* with a view to identifying which method(s) preserve the minerals and the mineral safety index.

Materials and Methods

Collection of Samples: The samples of African breadfruit (*Treculia africana*) seeds were obtained from a local farm in Odo-Ayedun town in Ekiti State, Nigeria. The samples were certified in the Department of Plant Science, Ekiti State University, Ado-Ekiti. The seeds were properly sorted to remove the defected ones.

Treatment of samples: About 1kg of the *Treculia africana* seeds used for the analysis was divided into three groups (about 350 g each for raw, roasted and cooked samples). These forms of samples were prepared following the method described by Adeyeye (2010). The seeds parts obtained were then homogenized separately and packed in plastic bottles and kept in freezer (–4°C) pending analysis.

Mineral analysis

Minerals were analyzed using the solutions obtained after dry ashing the samples at 550°C and dissolving it in 10 % HCl (25 ml) and 5 % lanthanum chloride (2 ml), boiling, filtering and making up to standard volume with deionized water. Phosphorus was determined colorimetrically using a Spectronic 20 (Gallenkamp, London, UK) instrument, with KH_2PO_4 as a standard. All other elements (Ca, Mg, Zn, Fe, Mn, Cu and Cr) were determined by atomic absorption spectrophotometry, Model 403 (Perkin-Elmer, Norwalk, Connecticut, USA). All determinations were made in duplicate. All chemicals used were of analytical grade, and were obtained from British Drug House (BDH, London, UK). Na and K were determined by flame photometer, Model 405 (Corning, Halstead Essex, UK) using NaCl and KCl to prepare the standards

The detection limits for the metals in aqueous solution had previously been determined just before the mineral analyses using the methods described in a book on Atomic Absorption Spectroscopy by Varian Techtron, giving the following values in µg/ml: Fe (0.01), Cu (0.002), Na (0.002), K(0.005), Ca(0.04), Mg(0.002), Zn (0.005), Mn (0.01) and Cr (0.02) (Varian Techtron, 1975). The optimal analytical range was 0.1 to 0.5 absorbance units with coefficients of variation from 0.9-2.2 %. The coefficients of variation per cent were calculated (Steel and Torrie, 1960). Mineral ratios (Ca/P, Na/K, Ca/Mg and the millequivalent ratio of [K/(Ca +Mg)]) were calculated as well as the mineral safety index (MSI) of Na, Mg, P, Ca, Fe and Zn (Hathcock, 1985).

Statistical analysis

Calculations made were the mean, standard deviation (SD) and coefficients of variation in percentage (CV %). The data obtained were also subjected to the determination of linear correlation coefficient (r_{xy}), linear regression (R_{xy}) and r_{xy} calculated compared to r_{xy} table at $r_{=0.05}$ and at n-1 degree of freedom to see if significant difference occurred among the samples; both the coefficient of alienation (C_A) and index of forecasting efficiency (IFE) were also calculated (Oloyo, 2001).

Results and Discussion

Table 1, depicts the mineral composition and computed minerals ratios of raw, roasted and cooked samples. Levels of minerals in the samples ranged as follows: Iron (Fe) in the raw (1.33 -3.61mg g/100g), roasted (8.94-22.1 mg/100g) and cooked (10.1- 24.4 mg/100g); Cu in the raw (0.416 – 1.14mg/100g), roasted (0.485- 1.21 mg/100g and cooked (0.538-1.21 mg/100g); Zn, in the raw (0.533 – 0.963 mg/100g), roasted (3.18- 6.12 mg/100g), cooked (3.67- 5.96); Pb and Cd are present in all the sample at a very insignificant level (<0.001- 0.001 mg/100g); Ca in the raw (22.4- 36.8 mg/100g); roasted (35.7- 87.0 mg/100g) and cooked (33.0- 80.8 mg/100g), Mg levels in the raw (36.4-

50.5mg/100g), roasted (172- 292 mg/100g) and cooked (165-283 mg/100g); K in the raw (462- 751 mg/100g); roasted (370- 619 mg/100g); cooked (352- 648 mg/100g); Na in the raw (22.9- 27.8 mg/100g), roasted (8.84 – 18.4 mg/100g) and cooked (7.09 -16.5 mg/100g) while phosphorus (P) levels in the raw was (75.9- 156 mg/100g), roasted (397-553 mg/100g), and cooked (419-585 mg/100g). The results (K, Ca, Mg, Fe, Zn and Cu) obtained in the present report were comparable to what had earlier been reported by Osabor *et al.* (2009) but comparably higher than the reports given by Ijeh *et al.* (2010) in Ca, Mg, Fe, and Cu for raw, boiled-dried, roasted whole seeds and roasted dehulled seed flours of *T. africana.*

Minerals are important in human nutrition. It is well known that enzymatic activities as well as electrolytic balance of the blood fluid are related to the adequacy of Na, K, Mg and Zn. Potassium is very important in maintaining body fluid volume and osmotic equilibrium, the pH of the body, regulation of muscles and nerve irritability, control of glucose absorption and enhancement of normal retention of protein during growth (NRC, 1989). Metal deficiency syndrome like rickets, and calcification of bone is caused by calcium deficiency.

Table 1. Mineral composition and computed mineral ratios of the raw, roasted and cooked samples of *Treculia africana* seed parts (mg/100g)

Minerals	RAW						ROASTED						COOKED					
	RWF	RDF	RTF	Mean	SD	CV%	RSWF	RSDF	RSTF	Mean	SD	CV%	CWF	CDF	CTF	Mean	SD	CV%
Fe	2.85	3.61	1.33	2.6	1.16	44.6	12.4	8.94	22.1	14.5	6.82	47.1	13.4	10.1	24.4	16	7.49	46.8
Cu	1.08	1.14	0.416	0.878	0.401	45.6	0.619	0.485	1.21	0.771	0.386	50	0.684	0.538	1.21	0.811	0.353	43.6
Co	0.001	0.001	<0.001	0.001	0	0	6.0e-4	5.0e-4	8.0e-4	6.3e-4	1.5e-4	24.1	5.0e-4	4.0e-4	6.0e-4	5.0e-4	1.0e-4	20
Mn	0.102	0.136	0.084	0.107	0.026	24.7	1.90	1.48	4.96	2.78	1.90	68.3	2.11	1.64	5.11	2.95	1.88	63.8
Ni	0.016	0.013	0.008	0.012	0.004	32.5	0.011	0.013	0.01	0.011	1.5e-3	13.9	0.014	0.012	0.012	0.013	0.0012	8.88
Zn	0.728	0.963	0.533	0.741	0.215	29	3.18	3.57	6.12	4.29	1.60	37.2	3.67	3.84	5.96	4.49	1.28	28.4
Pb	0.001	0.002	<0.001	0.001	0.001	6	<0.001	<0.001	<0.001	-	-	-	<0.001	<0.001	<0.001	-	-	-
Cd	0.001	0.001	<0.001	0.001	0	0	<0.001	<0.001	<0.001	-	-	-	<0.001	<0.001	<0.001	-	-	-
Ca	29.7	36.8	22.4	29.6	7.2	24.3	49.7	35.7	87	57.5	26.5	46.1	42.8	33	80.8	52.2	25.2	48.4
Mg	41.7	50.5	36.4	42.9	7.12	16.6	216	172	292	227	60.7	26.7	182	165	283	210	63.8	30.4
K	707	751	462	640	156	24.4	409	370	619	466	134	28.7	384	352	648	461	162	35.2
Na	25.8	27.8	22.9	25.5	2.46	9.64	10.6	8.84	18.4	12.6	5.09	40.4	8.79	7.09	16.5	10.8	5.01	46.4
P	148	156	75.9	127	44.1	34.7	411	397	553	454	86.3	19	427	419	585	477	93.6	19.6
Se	0.003	0.004	0.002	0.003	0.001	33.3	0.016	0.017	0.015	0.016	0.001	6.25	0.017	0.019	0.016	0.017	0.0015	8.99
Ca/P	0.201	0.236	0.295	0.244	0.048	19.5	0.121	0.09	0.157	0.123	0.034	27.4	0.10	0.079	0.138	0.106	0.03	49.8
Na/K	0.036	0.037	0.05	0.041	0.008	19.1	0.026	0.024	0.03	0.027	0.003	11	0.023	0.02	0.058	0.034	0.021	62.1
Ca/Mg	0.712	0.729	0.615	0.685	0.062	8.98	0.23	0.208	0.298	0.245	0.047	19.2	0.235	0.20	0.286	0.24	0.043	18
K/Na	27.4	27.0	20.2	25.1	63.4	2.53	38.6	41.9	33.6	38	4.14	10.9	43.7	44.6	39.3	42.5	2.84	6.67
K/(Ca+Mg)*	19.8	17.2	15.7	17.6	2.07	11.8	3.08	3.56	3.27	3.30	0.244	7.40	3.42	3.56	3.56	3.51	0.081	2.30

*Milliequivalent, RWF=raw wholeseed flour, RDF =raw dehulledseed flour, RTF=raw testa flour, RSWF= roasted wholeseeds flour, RSDF=roasted dehulled seed flour, RSTF= roasted testa flour, CWF=cooked whole seed flour, CDF= cooked dehulled seeds flour, CTF= cooked testa flour, CV = coefficient of variation, SD= standard deviation

Fe and Ca requirements increase by about 10-50% from early infancy through 2 years of age. Calcium plays important role on bone and tooth development, blood clothing and maintaining healthy nerves and muscles. The mg/100g levels of Na, K, Ca, Fe and Mg in all the samples can meet the DRI and WHO recommended values for fortified complementary foods for 6-23months and the needs from complementary food by level of usual breast milk intake (low, average, high) for 6-23 months old infants (WHO,1998).

The major minerals in the samples were fairly comparable to the values reported by Adeyeye (2011) for groundnut seeds flour and level reported for fatted and defatted marble vine seeds (Adeyeye and Adesina,2012). Non-heme iron is found in cereals and legumes where infants receive most iron as non-home iron. Iron is required for proper growth, formation of healthy blood cells, hemoglobin and part of myoglobin and many enzymes of foods prevent irreversible behavioural abnormalities and abnormal functioning of the brain (NRC, 1989 and WHO,1998). The range of iron levels in the samples compares favourably with the 16.66 mg/100g reported by Mune *et al.* (2013) for bambara groundnut except in the raw samples which was lower in the present report, comparably close to the values reported for sorghum (10.8 mg/100g) and maize (8.1 mg/100g), lower than values in millet and rice (30.9 and 24.3 mg/100g respectively) (Adeyeye and Ajewole, 1992). Fe requirement by humans is 10-15mg for children, 18mg for women and 12mg for men (Fleck, 1976). Except the raw, which could only meet 25% of these requirements, roasted and cooked could meet up to 90-100% of requirement. Zinc dietary deficiency has been found in adolescent boys in the Middle East eating a poor diet based largely on unleavened bread (Bender, 1992).

The phosphorus levels of (75.9-156mg/100g) raw, (397-553 mg/100g) roasted and (419-587 mg/100g) cooked samples were on the average about half of the recommended daily allowance (RDA) levels of 800mg. Also the calcium levels of (22.4-36.8mg/100g) raw, (35.7- 89.0 mg/100g) roasted and (33.0- 80.8mg/100g) cooked samples were much lower than the RDA level of 800g (Adeyeye, 2011). If calcium is adequately present in the diet, Fe is utilized to better advantage. This is an instance of “sparing action” (Fleck, 1976). Roasting and cooking enhanced the levels of phosphorus by almost 200%. The Zn levels in the samples were comparably lower than the Zn allowance of about 15-20mg per day (Fleck, 1976). Magnesium is required for growth, maintenance of bones and proper formation of nerves and muscles. High fibre foods are high in magnesium (WHO, 1998). Because magnesium is relatively high in cereals and legumes as typified in the present report, the deficiency is not common in infants (meets the WHO recommended value for fortified complementary foods for 6-8months infants based on safe nutrient intake from British Dietary Reference values (WHO, 1998). Manganese is needed by infants for proper functioning of the spinal cord because manganese deficiency leads to defective growth of central nervous system. Co is a component of vitamin B12 (cyanocobalamin) which is essential for the prevention of anemia (Bender, 1992). The levels of Co in the samples were generally low. Cu and Fe are present in the enzyme cytochrome oxidase involved in energy metabolism. Since Co, Cu and Cr are needed in the diet, the present samples would need to be supplemented in these minerals when they serve as a sole source of food. The levels of Cu in the samples were averagely lower compared to the levels in maize (6.2 mg/100g) but comparably higher than the levels reported for sorghum, millet and rice (0.30 – 0.60 mg/100g) (Adeyeye and Ajewole, 1992). Mn, Co, and Cu were reported undetected in bambara groundnut seeds (Olaleye *et al.,* 2013). It is gratifying that both Pb and Cd were of levels less than 0.001 mg/100g, since both metals were not needed in the body for any biochemical process. However their presence may indicate the onset of pollution in the environment where the samples were collected.

The sodium and potassium levels in this report were within the values reported for some legumes: *Canavalia ensiformis* (5.80-16.70 mg/100g Na; 450-2860 mg/100g K) and *Canavalia gladiate* (0.26 -83.9 Na; 790-2280 mg/100g K) (Sridhar and Seena, 2006). On the other hand, the values were comparably higher than what was reported for bambara groundnut seeds (Na-Testa: 12.2 mg/100g), dehulled seeds: 24.9 mg/100g and wholeseeds: 23.9 mg/100g; K-Testa 25.8mg/100g, dehulled 49.3mg/100g and wholeseeds: 50.7 mg/100g) (Olaleye *et al.,* 2013), and also in some vegetable samples : *Bridelia ferruginea* (Na-16.6 and K- 29.8 mg/100g) (Adesina and Akomolafe, 2014); *Amaranthus hybridus* (Na- 64.6 mg/100g, K-11.0mg/100g, *Cucurbita pepo* (Na- 36.8 mg/100g, K-9.0mg/100g) (Iheanacho and Udebuani, 2009); *Cnidoscolus Chayamansa* (K– 4.02 mg/100g); *Solanum nodiflorum* (K- 0.19mg/100g) and S*enecio biafrae* (K- 0.18mg/100g) (Adeleke and Abiodun, 2010). Levels of K in the present results were higher, alluding to the fact that plant materials are expected to contain higher level of potassium with low level of Na. The levels of K in all the forms of our present samples were comparably higher than the levels reported for cereals commonly consumed in Nigeria (sorghum, millet, maize and rice 325- 450mg/100g) (Adeyeye and Ajewole, 1992).

Table 1, also depicts the various mineral ratios that were computed (Ca:P, Na:K, K:Na, Ca:Mg and [K:(Ca +Mg)]. The entire CV% of all the sample groups were low (2.53- 19.5 for raw, 7.4- 27.4 for roasted and 2.30 – 62.1 for cooked).

Modern diets, which are rich in animal proteins and phosphorus, may promote the loss of calcium in the urine (Shils and Young, 1988). This has led to the concept 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 lost in the urine, which result to decrease in calcium level of the bones. In animals, a Ca/P ratio above two (twice as much calcium as phosphorus) helps to increase the absorption of calcium in the small intestine. The Ca:P in the present report were generally lower than 0.5 which is the minimum ratio required for favourable Ca absorption in the intestine for bone formation (NRC, 1989 and Nieman *et al.,* 1992). These levels of Ca:P ratio would not promote strong bone development to a large extent as expected since absorption under this condition would be low. The Ca:P ratio is reported to have some effect on Ca in the blood of many animals (Adeyeye and Faleye, 2007). For the prevention of high blood pressure, a Na/K ratio of 0.60 is recommended (Nieman *et al.,* 1992). The Na/K ratio in our samples were all lower than 0.60. In other words, the samples would not promote high blood pressure disease. Foods that have low sodium, high-potassium values include mostly fruits, vegetables, and low sodium cereals (Nieman *et al.,* 1992) which could serve as complementary to foods that are low in potassium. The Ca:Mg ratio in all the samples ranged between 0.615-0.729 for raw, 0.208 – 0.298 for roasted and 0.200 – 0.286 for cooked samples, whereas the recommended value is 1.0. Both Ca and Mg would need adjustment for good health. The milliequivalent ratios of [K: (Ca + Mg)] were all higher than 2.2. This indicates that the sample may likely promote hypomagnesaemia in man (NRC, 1989). Similar observation had also been made by Olaleye *et al.,* (2013) in the samples of various parts of bambara groundnut.

The effects of processing on the minerals composition of the raw are depicted in Table 2. The following minerals were enhanced in the raw whole seeds, raw dehulled seeds and raw testa (Fe, Zn, Mg, P, Se) by roasting and cooking. Whereas the highest percentage of enhancement as observed from our sampleS during roasting and cooking were: Fe (roasted testa flour –1562%) and -1735% in cooked testa flour; Mn (-1735% roasted whole seeds flour), roasted testa flour (-5805%) and cooked testa flour (-5983%). For Ca the highest percentage enhancement was observed in the roasted testa flour (-288%) and cooked testa flour (-261%), for Mg the enhancements were also noticed in the testa (both roasted and cooked) i.e -702% and -677% respectively. Similar observation was also seen in the levels of phosphorous, i.e -629% and -671% in roasted and cooked testa respectively. The trend was also similar for selenium.

In general 58.3% of all the minerals were enhanced in all the samples with respect to processing while 41.7% of all were better in the raw sample with the exception of Pb and Cd, since the two elements were virtually present in an insignificant level.

Among the computed minerals ratios, Ca:P, Na:K, Ca:Mg and [K:(Ca + Mg)] were all better in the raw samples when compared with the roasted and cooked samples. This is an indication that both roasting and cooking do not elevate any of these ratios with the exception of cooked testa flour in Na:K where the ratios were enhanced.

Mineral Safety Index

The minerals safety indexes of the samples are depicted in Table 3. The standard minerals safely index (MSI) for the minerals are Na (4.8), Mg (15), P (10), Ca (10), Fe (6.7), Zn (33), Cu (33), Se (14). For Ca, P, Zn, Cu, Se, Fe, and Na, all MSI values were low except for Fe in the roasted testa flour and cooked testa flour where the values were greater than 6.7 (i.e 9.88 and 10.9 respectively), the rest had positive values for the difference between the standard MSI and the calculated values of MSI. This meant that the sample might not be overloading the body in these minerals. Abnormal high levels of Na, Mg and P in any food could cause the reduction of zinc in the small intestine (O'Dell, 1984), the abnormal high level of iron in the roasted and cooked testa sample could lead to iron poisoning particularly in children (Herbert, 1987).

Table 2. Summary of the differences in minerals and computed mineral ratios from Table 1

	RWF-RSWF(%)	RDF-RSDF(%)	RTF-RSTF(%)	RWF-CWF(%)	RDF-CDF(%)	RTF-CTF(%)
Minerals						
Fe	-9.55(-335)	-5.33(-148)	-20.8(-1562)	-10.6(-370)	-6.49(-180)	-23.1(-1735)
Cu	+0.461(+42.7)	+0.655(+57.5)	-0.794(-191)	+0.396(+36.7)	+0.602(+52.8)	-0.794(-191)
Co	+0.0004(+40.0)	+0.001(+50.0)	0.00(0.00)	+0.001(+50.0)	+0.001(+60.0)	0.00(0.00)
Mn	-1.80(-1736)	-1.34(-988)	-4.88(-5805)	-2.01(-1969)	-1.50(-1106)	-5.03(-5983)
Ni	-0.005(+31.3)	0.00(0.00)	-0.002(-25.0)	+0.002(+12.5)	+0.001(+7.69)	-0.004(-50.0)
Zn	-2.45(-337)	-2.61(-271)	-5.59(-1048)	-2.94(-404)	-2.88(-299)	-5.43(-1018)
Pb	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Cd	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Ca	-20.0(-67.3)	+1.10(+2.99)	-64.6(-288)	-13.1(-44.1)	+3.80(+10.3)	-58.4(-261)
Mg	-174(-418)	-122(-241)	-256(-702)	-140(-336)	-115(-227)	-247(-677)
K	+298(+42.1)	+381(+50.7)	-157(-34.0)	+323(+45.7)	+399(+53.1)	-186(-40.3)
Na	+15.2(+58.9)	+19.0(+68.2)	+4.50(+19.7)	+17.0(+65.9)	+20.7(+74.5)	+6.40(+27.9)
P	-263(-263)	-241(-154)	-477(-629)	-279(-189)	-263(-169)	-509(-671)
Se	-0.013(-433)	-0.013(-325)	-0.013(-650)	-0.014(-467)	-0.015(-375)	-0.014(-700)
Ca/P	+0.08(+39.8)	+0.146(+61.9)	+0.138(+46.8)	+0.101(+50.2)	+0.157(+66.5)	+0.157(+53.2)
Na/K	+0.01(+27.8)	+0.013(+35.1)	+0.02(+40.0)	+0.013(+36.1)	+0.017(+45.9)	-0.008(-16.0)
Ca/Mg	+0.482(+67.7)	+0.521(+71.5)	+0.317(+51.5)	+0.477(+67.0)	+0.529(+72.6)	+0.329(+53.5)
K/Na	-38.6(-1409)	-41.9(-1552)	-33.6(-1352)	-43.7(+1021)	-44.6(+1121)	-39.3(-1321)
K/(Ca+Mg)*	+16.7(+84.4)	+13.6(+79.3)	+12.4(+79.2)	+16.4(+82.7)	+13.6(+79.3)	+12.1(+77.3)

Taking Zn again as example, the levels in all the samples were less than the MSI (33) given. This meant the entire sample have Zn values within the recommended adult intake. The minimum toxic dose is 500mg, 33 times the RDA (Hathcock, 1985). High doses of Zn can be harmful. Zinc supplement can decrease the amount of high density lipoprotein circulating in the blood, increasing the risk of heart disease. Excess zinc interacts with other minerals, such as copper and iron thereby decreasing their absorption. In animals, zinc supplement decreases the absorption of iron so much that anemia is produced (Greger, 1987). When patients are given 150mg of zinc per day, copper deficiency results. Intakes of zinc at only 3.5mg/day above the RDA decrease copper absorption. In animals, copper deficiency causes scarring of the heart muscle tissue and low levels of calcium in the bone (NRC, 1989). Excess zinc also decreases the functioning of the immune system (Adeyeye and Faleye, 2007).

Table 3. Mineral safety index (MSI) of raw, roasted and cooked samples of *Treculia africana* seed parts

Mineral		RAW						ROASTED						COOKED					
		RWF		RDF		RTF		RSWF		RSDF		RSTF		CWF		CDF		CTF	
	TV	CV	D	CV	D	CV	D	CV	D	CV	D	CV	D	CV	D	CV	D	CV	D
Ca	10	0.25	9.25	0.31	9.7	0.19	9.81	0.41	9.59	0.30	9.70	0.70	9.27	0.36	9.64	0.28	9.72	0.67	9.33
P	10	1.24	8.76	1.30	8.7	0.63	9.37	3.42	6.58	3.31	6.69	4.61	5.39	3.56	6.44	3.48	6.52	4.87	5.13
Mg	15	1.56	13.4	1.89	13.1	1.37	13.6	8.10	6.90	6.45	8.55	11.0	4.0	6.83	8.17	6.19	8.81	10.6	4.40
Fe	6.7	1.27	5.43	1.62	5.10	0.59	6.11	5.54	1.16	3.40	3.30	9.88	-3.2	5.99	0.71	4.52	2.18	10.9	-4.20
Zn	33	1.60	31.4	2.12	30.9	1.17	31.8	7.00	26.0	7.85	25.2	13.5	19.5	8.07	24.9	8.45	24.8	13.1	19.9
Cu	33	11.9	21.1	12.5	20.5	4.58	28.4	6.81	26.2	5.34	27.7	13.3	19.7	7.52	25.5	5.92	27.1	13.3	19.7
Se	14	0.60	13.4	0.80	13.2	0.40	13.6	3.20	10.8	3.40	10.6	3.00	11.0	3.40	10.6	3.80	10.2	3.20	10.8
Na	4.8	0.08	4.76	0.07	4.73	0.22	4.58	0.10	4.78	0.09	4.71	0.18	4.62	0.08	4.72	0.07	4.73	0.16	4.64

TV= table value, CV= calculated value, D=difference (TV-CV)

Table 4. Results of statistical analysis (linear correlation) of the data from Table 1

Sample	Groups of parameters	r_{xy}	r_{xy}^2	R_{xy}	C_A%	IFE %	TV ($_{\alpha=0.05,df=n-1}$)	Remark
Hulled	RWF/RSWF	0.77696	0.60367	0.58034	63.0	37.0	0.4680	S
	RDF/RSDF	0.77030	0.59336	0.56945	63.8	36.2	0.4680	S
	RTF/RSTF	0.79603	0.63366	0.61211	60.5	39.5	0.4680	S
	RWF/CWF	0.75755	0.57388	0.54881	65.3	34.7	0.4680	S
	RDF/CDF	0.75880	0.57578	0.55803	65.1	34.9	0.4680	S
	RTF/CTF	0.79868	0.63789	0.61660	60.2	39.8	0.4680	S
Dehulled	RWF/RDF	0.99992	0.99984	0.99983	1.30	98.7	0.4680	S
	RSWF/RSDF	0.99771	0.99543	0.99515	6.76	93.2	0.4680	S
	CWF/CDF	0.99335	0.98674	0.98597	11.5	88.5	0.4680	S

TV= table value ($_{r=0.05,df=n-1}$), C_A= coefficient of alienation, IFE= index of forecasting efficiency, S= significant

Statistical analysis

The statistical summary of the data from Table 1 is shown in Table 4. The linear correlation coefficient (r_{xy}) was high in the comparisons made: RWF/RSWF, RDF/RSDF, RTF/RSTF, RWF/CWF, RDF/CDF, RTF/CTF (minerals) and effects of dehulling on the whole seeds flour (RWF/RDF, RSWF/RSDF, CWF/CDF). There was significant difference between the raw and roasted as well as between the raw and cooked samples at $r_{=0.05}$. The variance (r_{xy}^2) follow similar trend as in r_{xy} . The linear regression coefficient (R_{xy}) was equally positively high. This meant that for every unit rise (take for instance RWF/RSWF: raw whole seeds flour/ roasted whole seeds flour) in mineral content of raw whole seeds flour, roasted whole seeds flour would increase by 0.58034. The coefficient of alienation (C_A) was high in RWF/RSWF, RDF/RSDF, RTF/RSTF, RWF/CWF, RDF/CDF and RTF/CTF (60.2-65.3 %) and low in RWF/RDF, RSWF/RSDF, CWF/CDF (effects of dehulling) (1.26-11.5 %). This resulted into the corresponding low (34.7-39.8 %) and high (93.2 – 98.7 %) index of forecasting efficiency (IFE) respectively. The IFE value is a value of the reduction of the error of prediction of relationship between two variables or entities; the higher the value, the lower the error of prediction of relationship and the easier the prediction of relationship. Since RWF/RDF, RSWF/RSDF and CWF/CDF (effects of dehulling) were high, it shows that RWF can carry out the nutritional roles of RDF and vise versa, same for RSWF/RSDF and CWF/CDF.

Conclusion

This study showed that *Treculia africana seed flour* is a very good source of essential major minerals and trace elements Se and Mn. The Ca/P shows that both minerals will be highly absorbed in the body. The MSI shows that roasted and cooked testa flours (RSTF and CTF) contained iron at a level which may overlade the body (resulting in excess iron in the tissue of consumers). The sample is good enough to supplement food sources with deficient levels of many of the essential minerals. Since the seeds were usually been sold and consumed majorly in the Southern, South-Eastern and Eastern part of Nigeria, the research would further strengthens and encourages its sale and utilization domestically and industrially.

References

Adeleke R. O. and Abiodun O. A. (2011). Chemical Composition of Three traditional vegetables in Nigeria. *Pakistan Journal of Nutrition*, 9(9): 858-860. *DOI: 10.3923/pjn.2010.858.860*

Adesina A. J and Akomolafe S. F. (2014). Nutritional and Anti-nutritional Composition of *Bridelia Ferruginea* Benth (Euphorbiaceae) Stem Bark Sample. *International Journal of Scientific Research in Knowledge*, 2(2): pp. 92-104. *DOI: 10.12983/ijsrk-2014-p0092-0104.*

Adeyeye A. and Ajewole K. (1992). Chemical composition and fatty acid profiles of cereals in Nigeria. *Food Chemistry*, 44: 41-44. DOI: 10.1016/0308-8146(92)90255-Z

Adeyeye E. I, and Faleye F. J. (2007). Chemical composition and the food properties of *Kerstingiella geocarpa* harm seeds. *J. App. Environ. Sci.,* 3 (2): 150-157.

Adeyeye E. I. and Adesina A. J. (2012). Chemical composition and food properties of egg and muscle of turkey-hen compared. Proceedings of the 36th Annual Conference of NIFST, 15-19 October, EKO 2012, pp. 473-475.

Adeyeye E. I. (2010). Effect of cooking and roasting on the amino acid composition of raw groundnut (*Arachis* hypogaea) seeds. Acta Sci. Pol. Technol. Aliment. 9(2): 201-216.

Adeyeye E. I. (2011). Effects of processing on the nutritional and anti-nutritional factors of *Arachis hypogaea* Linn. (groundnut) seed flour. *Int. J. Chem. Sci*. 4(1): 131-142.

Baiyeri K. P. and Mbah B. N. (2006). Effect of Soiless and Soil-based Nursery Media on Seedling Emergency, Growth and Response to Water Stress of African Breadfruit (*Treculia africana* Decne). *African Journal of Biotechnology* 5(15): 1400-1405.

Bender A. (1992). Meat and meat products in human nutrition in developing countries. FAO Food and Nutrition Paper, 53, FAO, Rome, Italy, pp 46-47.

Enujiugha V. N and Ayodele-Oni O. (2003). Evaluation of nutrients and some anti-nutrients in lesser known underutilized oil-seeds. *Int. J. Food Sci. Tech*. 38: 525-8. *DOI: 10.1046/j.1365-2621.2003.00698.x*

FAO, (1985). The fifth world food survey. FAO, Rome.

Fleck H. (1976). Introduction to Nutrition, 3rd ed. Macmillan, New York, USA, pp 207-219.

Giami S. Y. and Wachuku O. C. (1997). Composition and functional properties of unprocessed and locally processed seeds from three underutilized food sources in Nigeria. *Plant Foods Hum Nutr.* 50: 27-36. *DOI: 10.1007/bf02436040.*

Greger J. L. (1987). Mineral bioavailability/ new concepts. *Nutr. Today* 22: 4–9. *DOI: 10.1097/00017285-198708000-00001*

Hathcock J. N (1985). Quantitative evaluation of vitamin safety. *Pharmacy Times*, 104-113.

Herbert V. (1987). Recommended dietary intakes (RDI) of iron in humans. *Am J. clin. Nutr.*, 45: 679-686. *DOI:10.3923/pjn.2010.751.754*

Iheanacho M. E and Udebuani A. C (2009). Nutritional Composition of some leafy vegetables consumed in Imo State, Nigeria. *J. Appl. Sci. Environ. Manag.,* 13(3): 35-38. *DOI:10.4314/jasem.v13i3.55349*

Ihnat M. (1988). Pick a number -Analytical data reliability and biological reference materials. *Sci. Total Environ*. 71:85–103. *DOI:10.1016/0048-9697(88)90302-6*

Ijeh I. I., Ejike E. C., Nkwonta O. M and Njoku B. C. (2010). Effect of tradtional processing techniques on the nutritional and phytochemical composition of African breadfruit (*Treculia africana*) seeds. *J. Appllied Science and Environment Managemet,* 14(4): 169-173. *DOI:10.4314/jasem.v14i4.63314*

Irvine J. I. (1981). Comparative study of the Chemical Composition and Mineral element content of *Treculia africana* seeds and seed oils. *Journal of Food Engineering*, 40: 241-244.

Latham M. C. (1997). Human Nutrition in the Developing World. Food and Nutrition Series No 29, Food and Agriculture Organization of the United Nations, (FAO) Rome.

Mune M. A., Mbome L. I. and Minka S. R. (2013). Chemical composition and nutritional evaluation of a cowpea protein concentrate. *Global Advanced Research Journal of Food Science and Tech*., 2 (3):035-043.

National Research Council (NRC), (1989). Food and Nutrition Board Recommended Dietary Allowances (10th Edition). National Academy Press Washington D.C.

Nieman D. C., Butterworth D. E., Nieman C. N (1992). Nutrition, Wm. C. Brown Publishers. Dubuque.

O'Dell B. L. (1984). Bioavailability of trace elements. *Nuts. Rev*., 42: 301-307. *DOI:10.1111/j.1753-4887.1984.tb02370.x*

Okafor J. C. (1985). Selection and improvement of indigenous Tropical fruit Trees: problems and prospects. *Jour. For. Res*. 1 (2): 87-95.

Okafor J. C. and Okolo H. C. (1974). Potentials and Some Indigenous Fruit Trees of Nigeria. Paper Presented at the 5th Annual Conference of the Forestry Association of Nigeria, Jos.

Okafor J. C. (1990). Indigenous Trees of the Nigerian Rainforest. A Paper Presented in a Symposium on the Potentials for Domestication and Rebuilding of Forest Resources. Yaounde, Cameroon, pp.34-38.

Olaleye A. A., Adeyeye E. I. and Adesina A. J. (2013). Chemical composition of bambara groundnut (*V. subterranea* L. Verdc) seed parts. *Bangladesh J. Sci. Ind. Res.* 48(3):167-178. *DOI:10.3329/bjsir.v48i3.17325*

Oloyo R. A. (2001). Fundamentals of Research Methodology for Social and Applied Sciences. ROA Educat. Press Ilaro.

Onyekwelu J. C. and Fayose O. J. (2007). Effect of Storage Methods on the Germination and Proximate Composition of *Treculia africana* Seeds. Paper Presented at the Conference on International Agricultural Research for Development. Tropentas, Germany.

Osabor V. N., Ogar D. A., Okafor P. C and Egbung G. E. (2009). Profile of the African breadfruit (*Treculia africana*). *Pakistan Journal of Nutrition*, 8(7): 1005-1008. *DOI:10.3923/pjn.2009.1005.1008 Actions*

Shils M. E. G and Young V. R (1988). Modern Nutrition in health and disease, Lea and Febiger, Philadelphia USA, In: Nutrition, eds Nieman, D.C, Butterworth, D.E, Nieman, C.N, 1992. WMC Brown Publisher, Dubuque, USA, Pp 276-282.

Sridhar K. R and Seena S. (2006). Nutritional and antinutritional significance of four unconventional legumes of the genus *canavalia*- a comparative study. *Food Chemistry*, 99: 267-288. *DOI:10.1016/j.foodchem.2005.07.049*

Steel R. G. D and Torrie J. H. (1960) *Principles and Procedures of Statistics*. McGraw-Hill. London.

Varian T., (1975). *Basic Atomic Absorption Spectroscopy-A Modern Introduction*. Dominica Press. Victoria.

WHO, (1998). Complementary feedings of infants and young children. Report of a Technical Co`nsultation supported by WHO/UNICEF. University of California/ Davies and ORSTOM, WHO, NUT, 96-9.

World Agroforestry Centre (WAC) (2004). *Treculia africana*. *In:* Agroforestry Database *http://www.worldagroforestry.org/sea/products/*afdbases/af/asp/speciesInfo.asp?SpID=1651, Retrieved on 02/08/2015.