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Mineral composition of ready-to-eat walnut kernel (*Tetracarpidium conophorum*) from southeast Nigeria

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ABSTRACT

Walnut is considered a delicacy in Nigeria. Elements were determined in 30 composite samples of cooked walnut kernel from Southeastern Nigeria by atomic absorption spectrophotometry (AAS) after acid digestion. Mean concentrations (mg/kg; dry weight) of K, Ca, Mg, Na, Fe, Zn, Cu and Pb were 2367±160, 882±120, 274±11, 183±67, 73.6±20, 37±7, 15.1±1.6 and 0.021±0.009 res pectively. Daily intake (mg/day) of Na (12–14), K (161–178), Ca (60–66), Mg (18–20), Fe (5.0–5.6), Cu (1.0–1.1) and Zn (2.5–2.8) on consuming 68–75 g of cooked walnut kernel were adequate when compared with their recommended daily intakes (RDI). The results indicated that though Pb was present, the daily Pb intake on consuming 68–75 g of walnut kernel is about 0.6% of the RDI (Pb RDI = 0.25mg/day). One-way ANOVA showed that sampling areas significantly influenced the levels of metals in cooked walnut kernel. Principal component analysis (PCA) indicated that metals were of natural source. The results proved Tetracarpidium conophorum kernel to be a rich source of essential minerals with negligible levels of toxic metals. The work contributes to the data on mineral composition of local foods and the results may be useful for the estimation of dietary information.

Keywords: *Tetracarpidium conophorum*, Nigerian walnut, metals, daily intake, micronutrients

INTRODUCTION

Nuts are highly valued and patronized by almost all age groups. They are rich in unsaturated fatty acids and other nutritional compounds such as minerals, protein, carbohydrate and fibre. Nuts are highly beneficial to human health because of their unique composition [1, 2]. Among the nuts that contain mostly monounsaturated fatty acids, walnuts are considerably rich in omega-6 and omega-3 polyunsaturated fatty acids [3]. These compounds are also favorable to human health, since they may supply some protection against coronary heart disease [4, 5]. Walnut, a common name for small flowering plant, is very important because of the nuts and timber most of them produce for the representative genus [6]. Walnut comprises such families as *Juglandaceae* (English walnut), *Euphorbiaceae* and *Olacaceae* (African walnut) [7]. Each family has its own peculiar characteristics but they have some things in common- the nuts. Walnuts (*Juglans regia* L.) are widely distributed all over the world, and they are common in China [8]. Although walnuts are rich in fat, a diet supplemented with walnuts had a beneficial effect on blood lipids, lowering blood cholesterol and lowering the ratio of serum concentrations of low deroity lipoprotein: high density lipoprotein by 12% [10, 11]. Walnut kernel generally contains about 60 % oil [12] but this can vary from 52 to 70 % depending on the cultivar, location grown and irrigation rate [11, 13–17].

Tetracarpidium conophorum (Nigerian walnut) trees are found in Uyo, Akamkpa, Akpabuyo, Lagos, Kogi, Ajaawa-Ogbomoso and Ibadan [6]. They are also found in Imo and Abia States, but not as ubiquitous as in afore mentioned cities. This plant is cultivated principally for the nuts which are cooked and consumed as snacks [18]. *Tetracarpidium conophorum* is known in the Southern Nigeria as *ukpa* (Igbo Language of Southeastern Nigeria) and in the Western Nigeria as *awusa or asala* (Yoruba Language of Western Nigeria) [19]. Walnut kernel possesses a bitter taste, which is usually observed upon drinking water immediately after eating it. This could be attributed to the presence of chemical substances such as alkaloid [6, 7]. Walnuts are of a high economic interest to the food industry [20] and its nuts are highly appreciated for its unique organoleptic characteristics [21], hypocholesterolemic effects [22, 23–25] and antihypertensive effect [22, 26–27].

In recent times, researchers have been exploring the composition of walnut woods, roots, barks, seed shells and kernels for nutritional and therapeutic functions [3, 19]. The result of the mineral composition clearly shows that *Tetracarpidium conophorum* seed could be a rich source of mineral elements [7]. Moreover, authors who examined the elemental composition of *Tetracarpidium conophorum* (Nigeria walnut) seeds and roots reported macro elements such as Ca, Mg, K, Na, etc. and micro elements including Cr, Cu, Mn, Zn, etc. without considering toxic metals like Pb [6, 7], although Edem and co-workers reported Pb as not detected [19]. Though some toxic metals have been useful in pharmaceutical preparations [28, 29, 30], they are well known pollutants [31, 32, 33]. Due to the various health implications of regular consumption of foods containing high level of Pb [34, 35], this research assessed the elemental (macro, micro and toxic) content of walnut kernel from Southeastern Nigeria and estimating their daily intakes. This result would be a useful tool in food composition database.

MATERIALS AND METHODS

Sampling and sample pre-treatment

Walnuts were sampled from five towns in Abia State (namely: Arochukwu, Isuikwuato, Isuochi and Umuahia) and five towns in Imo State (namely: Mbaise, Mgbidi, Okigwe, Orlu and Owerri). Within each of the ten towns investigated, samples were purchased at three different locations, making a total of thirty (30) composite samples. The samples were purchased as processed product displayed for sale. The shell was removed and the kernel dried to constant weight at 105 °C in an oven for 6 h, allowed to cool before they were crushed in porcelain mortar, homogenized, and packed in new sealable polyethylene bags. A total of 30 composite samples were analyzed.

Elemental analysis

Pulverized dried walnut samples were passed through 2 mm sieve. 1 g was then ashed in a muffle furnace at temperature of 450 °C for 5 h. After ashing was complete, the sample was quantitatively transferred into a 250 ml conical flask. Next, 10 ml of the digestion acid mixture (ratio 1:2:2 of perchloric, nitric and sulphuric acids) was added into the sample and gently heated on a hot plate in a fume hood until a white fume was observed which signified that digestion was complete. The digest was allowed to cool and 20 ml of distilled water was added to bring the minerals into solution; and filtered using ashless Whatman filter paper into a 100 ml calibrated volumetric flask and made up to mark with distilled water. The sample digests were subsequently analyzed for Ca, Cu, Fe, K, Mg, Na, Pb, Zn using Buck 200A (Buck Scientific; Norwalk, CT, USA) flame atomic absorption spectrophotometer**.**

Quality assurance

Appropriate quality assurance procedures and precautions were carried out to ensure the reliability of the results of the present study. Samples were generally carefully handled to avoid contamination. All chemicals used were of analytical grade: HNO_3 (69%, BDH Laboratory Supplies, Poole, England); H_2SO_4 (98%, BDH Laboratory Supplies, Poole, England); $HClO_4$ (70%, Sigma-Aldrich, USA). To eliminate the risk of contamination during the experiments, all plastic and glassware were carefully cleaned by washing, rinsing severally with tap water, and then soaking in 5% HNO_3 solution for a minimum of 24 h. Thereafter, they were rinsed severally with deionized water before use. Reagent blank determinations were used to correct the instrument readings. The accuracy of the analytical method was verified by analyzing a certified reference material (Accu Standards, New Haven Connecticut, USA). A recovery test of the total analytical procedure was carried out for some of the metals in selected samples by spiking analyzed samples with aliquots of metal standards and then re-analyzing the samples. Detection limit is defined as the concentration corresponding to three times the standard deviation of seven blanks.

Statistical analysis

Statistical analyses of data were carried out using SPSS 16.0 for windows (SPSS Inc., Polar Engineering and Consulting 2007) and Excel 2007 statistical package programs. One-way ANOVA was employed to check if significant differences exist for mean metal concentrations in walnut with respect to the sampling areas. The mean differences were considered significant at $p < 0.05$. Similarly, two–tailed correlation analyses of metals in sampled areas were conducted. The aim of PCA in this study was to visually explore the principal attributes of the analytical data and distribution of elements concentrations in walnut, which will be difficult to recognize with tables alone. PCA is a variable-reduction technique that carries out a linear transformation of a set of observations of perhaps correlated variables to generate a new set of values of linearly uncorrelated variables called the principal components (PCs). PCs can be calculated when given a set of data with *n* variables. Usually, the first PC is the linear combination with the maximum sample variance among all linear combinations of the variables. Each subsequent PC is the linear combination of the variables that has the greatest possible variance and is uncorrelated with all previously defined components [36]. Varimax normalized rotation is aimed at maximizing the variances of normalized factor loadings across variables for each factor [37].

Estimation of daily intake of metals

Abbey and co-workers identified that the supplementation of a background diet (based on a reference Australian diet) with 68 g of walnuts/day reduced the total and low-density lipoprotein cholesterol by 5 and 9 %, respectively [38]. Again, Spaccarotella and co-workers [39] reported the consumption of 75 g in their study of the effect of walnut intake on factors related to prostate and vascular health in older men. Based on the above studies, the consumption of walnuts of quantities ranging from 68 and 75 g was chosen to estimate metal intake by consumers. Thus, the daily intakes of Ca, Cu, Fe, K, Mg, Na, Pb and Zn from walnut kernel were estimated based on 68 and 75 g using the mean results of the study. The values obtained were then compared with the recommended daily intake (RDI) of 800, 4700, 350 and 2400 mg/day for respectively [40]; 0.25 mg/day for Pb [41]; 2, 18 and 15 mg/day for Cu, Fe and Zn respectively [42].

RESULTS AND DISCUSSION

Validation of the analytical method

Certified reference material (CRM) was analyzed in triplicate and the results are presented in Table 1. Recoveries for the CRM varied from 99.5 – 100.1%. Also, a recovery test of the total analytical procedure carried out for some of the metals in selected samples showed good recoveries between 99.4 and 100.4% (Table 2).

Table 1. Elements concentration in certified reference material (Accu standards USA)

Element	Certifies value (mg/L)	Our value [b] (mg/L)	Recovery (%)
Ca	7.5 ± 3.5	7.48 ± 3.54 [a]	99.7
Cu	0.38 ± 0.18	0.373 ± 0.177	99.5
Fe	0.75 ± 0.35	0.747 ± 0.352	99.6
K	2.5 ± 0.7	2.49 ± 0.71	99.6
Na	7.5 ± 3.5	7.51 ± 3.56	100.1
Zn	0.19 ± 0.09	0.187 ± 0.089	99.7

[a] Mean ± standard deviation [b]n=3

Table 2. Elements from recovery analysis (mg/kg)

Element	Spiked concentration	Recovered concentration	Recovery (%)
Ca	841 ± 110 [a]	842 ± 110 [b]	100.2
Cu	13.13 ± 0.01	13.06 ± 0.02	99.4
Fe	84.28 ± 0.55	83.94 ± 0.42	99.6
K	2211.5 ± 3.5	2208 ± 8	99.8
Na	125.5 ± 1.4	125.04 ± 1.51	99.6
Zn	35.32 ± 5.28	35.45 ± 4.82	100.4

[a] Mean ± standard deviation [b]n=3

Elemental concentration of walnut

The results of the elemental determination of walnut according to sampling areas as well as the combined data were presented in Table 3. All results were reported on dry weight basis (the moisture content determined were stated underneath Table 3). Lead (Pb) contents of walnut have not been described by any of the several studies on walnut of different genotypes and cultivars. Nevertheless, Ali and co-workers studying the composition of some walnut cultivars grown in Pakistan reported that the Pb concentration of walnut could be in the range of 0.69 – 1.06 ppm [43]. The present study however found a much lower concentration of Pb in the range of 0.009 – 0.039 mg/kg. The highest concentration of Pb was found in samples from Mbaise (0.033 ± 0.005 mg/kg), while the minimum concentration was found in samples from Isuikwuato (0.010 ± 0.002 mg/kg). The Pb content of other areas increased in the order: Okigwe > Isuochi > Aba ≥ Orlu > Mgbidi > Umuahia > Arochukwu ≥ Owerri (Table 3). The low content of Pb in the walnut samples studied indicated that it could be from natural source only.

Copper and zinc concentrations ranged from 12 – 18.3 (mean: 15.1 ± 1.6) and 25 – 54 (mean: 37 ± 7) mg/kg respectively. A similar study in Nigeria on *Tetracarpidium conophorum* (Nigerian walnut) seeds reported Cu and Zn concentrations of 16.5 and 40 mg/kg respectively [7], which compared well with the mean Cu and Zn concentrations of the present study. Lavedrine et al. reported Cu and Zn concentrations of some walnuts grown in France and Califonia to be in the range of 1.1 ± 0.1 to 1.4 ± 0.1 mg/100g (11 ± 0.1 to 14 ± 0.1 mg/kg) and 1.9 ± 0.2 to 1.2 ± 0.1 mg/100g (19 ± 0.2 to 12 ± 0.1 mg/kg) respectively [44].

Samples from Okigwe contained the highest concentration of Fe (106 ± 11 mg/kg), while the least concentration was found in samples from Owerri (48.8 ± 2.6 mg/kg). It is interesting to note that Ayoola and co-workers also reported a concentration of 110 mgFe/kg for Nigerian walnut samples [7]. The overall mean Fe content of samples investigated is 73.6 ± 19.7 mg/kg. The present result was above some of the results reported in literatures [44–46].

Overall mean Na content of walnut studied is 183 ± 67 mg/kg (range, 101 to 315 mg/kg). Literature [7] on walnut seeds reports Na concentration of 4830 mg/kg, which is approximately 25 times the result of the present study; while some researchers reports relatively lower values [44, 45]. The total mean concentrations of K, Ca and Mg of this study were 2367 ± 160, 882 ± 120 and 274 ± 11 mg/kg respectively. Some studies of mineral content of walnut cultivars reported K concentrations of 423, 440 –700 mg/100g and 481 ± 12 – 358 ± 12 [45–47] respectively. Again, samples from Mbaise recorded very high amount of calcium (1107 ± 110 mg/kg), which was about 126% of the total Ca concentration (Table 3). Isuikwuato samples contained the least concentration of Ca (741 ± 41 mg/kg). Ayoola and co-workers also reported very high K concentration which is about 490% times our result. The results of similar studies from literatures compared well with our result [44–47]. Total mean Mg content (274 ± 11) of this study is lower than the concentrations (1711 mg/kg) reported in literature [7].

Assessment of metals intake

The assessment of the dietary intake of metals is very important. Presented in Figures 1(a & b) are the percentage metal intakes from consumption of walnuts compared to the recommended daily intakes (RDI). From the figures, it could be seen that although K intake on consumption of 68 or 75 g of walnut kernel was higher than the intakes of the others, its percentage to the RDI was lower. The reason is that K is a macro element and is needed in high quantities in the human body. Nonetheless, Cu intake ranges between 1.02 and 1.125 mg on consumption of 68 or 75 g of walnut kernel but it showed the highest percentage to the RDI. This is so because Cu is a micro element, which is required in minute quantity in the body. The percentage to RDI was 51 and 56.3% and thus, this intake amount would be enough to maintain the body's needed level of Cu without any attendant health risk. Percentages to RDI of Pb intake on consumption of 68 or 75 g of walnut kernel are 0.54 and 0.6% respectively. This shows that, though walnut kernel contains Pb, its intake is not in any way comparable to the RDI given for Pb in food, therefore Pb would not constitute health hazard.

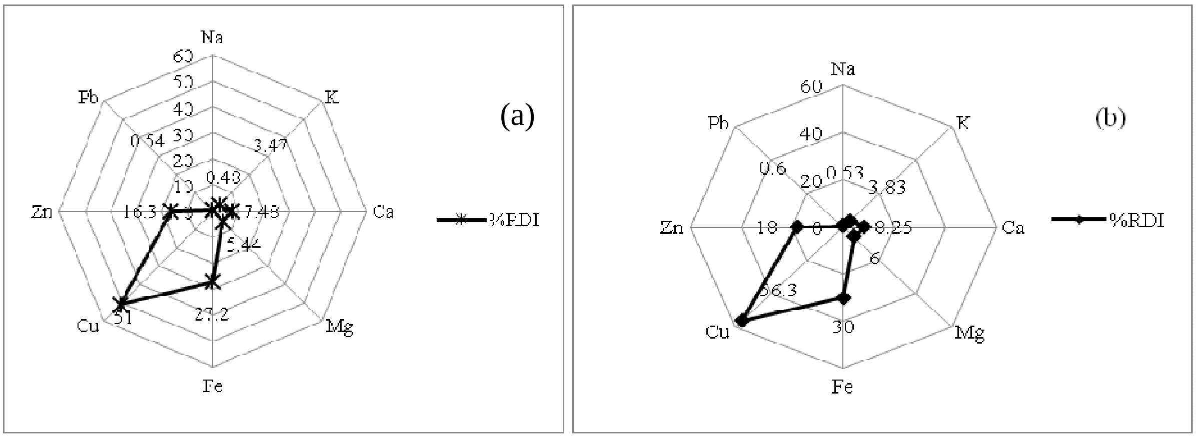

Figure 1a **Figure 1b**

Figure 1. Percentage intake of metals to RDI on consumption of (a) 68 g and (b) 75 g of kernel

Furthermore, the total metal intake was calculated using the overall mean concentrations of metals and quantity consumed (68 or 75 g). The consumption of 68 or 75 g of walnut kernel will furnish the body with 12.2 or 13.5 mg of Na daily. Therefore, walnut would serve as a source of sodium intake to man.

A consumer also derives 161.2 or 177.8 mg of K on consumption of 68 or 75 g of walnut per day. It could be seen that the amount of K taken into the body on eating walnut kernel is appreciable and will in no way bring about health concern to consumers.

The amount of Ca an individual receives on consuming 68 or 75 g of walnut kernel daily is 59.8 or 66 mg. Ca is well known for its function in bone formation and maintenance. Thus, walnut kernel would serve as a dietary source to supplement the amount of Ca derived from other sources.

Intakes of Fe and Zn on consumption of 68 or 75 g of walnut kernel are 5.03 - 5.55 and 2.52 - 2.78 mg/day respectively. Adequate intake of Fe is very important for decreasing the incidence of anaemia [48], while Zinc is known to be involved in most metabolic pathways in humans and its deficiency can lead to loss of appetite, growth retardation, skin changes and immunological abnormalities [49]. Therefore, walnut kernel would serve as a good source of these elements.

Copper is essential for good health but very high intakes could cause adverse health problems such as liver and kidney damage [50]. Also, its deficiency leads to hypochromic anemia, leucopenia and osteoporosis in children [51]. The amount of Cu derived from the consumption of 68 or 75 g of is 1.03 or 1.13 mg daily. These values are therefore, enough for liver and kidney functions without any attendant risks.

Mg and Pb intakes are in the ranges of 18.4 – 20.3 and 0.001– 0.002 mg per day on consumption of 68 – 75 g of walnut kernel. Thus walnut kernel will constitute a source of Mg supplement while Pb intake from walnut kernels is so small that it will constitute no health hazard.

Table 3 Elements content of walnut from areas in Southeastern Nigeria (mg/kg (dry weight); Mean (n= 3), Standard Deviation, Range and Median)

	Na	K	Ca	Mg	Fe	Cu	Zn	Pb
Aba	115 ± 13	2494 ± 25	938 ± 16	268 ± 8	84.2 ± 0.2	17.4 ± 0.9	46.5 ± 6.1	0.025 ± 0.004
	101 – 126	2467 – 2515	921 – 953	262 – 277	84.0 – 84.3	16.5 – 18.3	42.1 – 53.5	0.022 – 0.029
	118	2501	941	265	84.2	17.3	44	0.024
Arochukwu	118 ± 8	2485 ± 23	815 ± 60	256 ± 7	60 ± 7	14.2 ± 0.5	32 ± 1	0.012 ± 0.003
	109 – 125	2462 – 2507	774 – 883	251 – 264	53– 67	13.8– 14.7	30.6 – 33	0.01 – 0.02
	121	2487	786	253	61	14.2	31	0.01
Isuikwuato	135 ± 9	2026 ± 40	741 ± 41	258 ± 8	77.6 ± 6.6	12.6 ± 0.9	27.1 ± 1.8	0.010 ± 0.002
	125 – 143	1985 – 2064	713 – 788	251 – 267	71.6 – 84.7	12.0 – 13.7	25.4 – 29.0	0.009 – 0.012
	138	2030	723	256	76.5	12	26.7	0.009
Isuochi	284 ± 23	2223 ± 16	863 ± 70	275 ± 4	64.7 ± 9.5	16 ± 2	46.4 ± 4.2	0.028± 0.003
	259 – 304	2209 – 2241	785 – 920	273 – 279	54.6 – 73.4	13.8 – 17.4	41.6 – 49.4	0.025 – 0.031
	288	2220	884	273	66.2	16.9	48.3	0.028
Mbaise	176 ± 14	2502 ± 19	1107 ± 110	282 ± 4	53.0 ± 2.0	15.2 ± 0.4	42.3 ± 1.4	0.033 ± 0.005
	179 – 189	2488 – 2524	998 – 1218	277 – 286	50 – 55	14.9 – 15.6	40.6 – 43.2	0.029 – 0.031
	161	2495	1105	281	54	15.2	43	0.031
Mgbidi	163 ± 12	2429 ± 49	912 ± 23	278 ± 2	56.4 ± 0.8	17.5 ± 0.8	39 ± 1	0.016 ± 0.003
	149 – 172	2398 – 2486	890 – 935	277 – 280	55.7 – 57.3	17.0 – 18.0	38.7 – 40.6	0.012 – 0.018
	167	2404	912	278	56.2	17	39.1	0.018
Okigwe	236 ± 24	2427 ± 35	699 ± 11	274 ± 6	106 ± 11	13 ± 1	28.1 ± 2.2	0.030 ± 0.003
	209 – 254	2397 – 2465	689 – 711	267 – 280	98 – 119	12.1 – 13.8	26.4 – 30.6	0.027 – 0.033
	244	2420	698	274	100	13.1	27.2	0.031
Orlu	202 ± 8	2516 ± 15	877 ± 22	276 ± 3	95 ± 13	15.1 ± 0.5	33.4 ± 3.9	0.025 ± 0.004
	194 – 209	2499 – 2526	855 – 900	273 – 279	83.0 – 108	14.7 – 15.6	30.7 – 37.8	0.021 – 0.029
	202	2522	877	276	95	15	31.6	0.025
Owerri	115 ± 10	2262 ± 43	876 ± 15	288 ± 17	48.8 ± 2.6	15.2 ± 0.4	35.6 ± 2.6	0.012 ± 0.003
	103 – 124	2214 – 2297	859 – 887	269 – 301	46.3 – 51.5	14.9 – 15.6	33.7 – 38.5	0.009 – 0.014
	117	2274	881	295	48.7	15.1	34.5	0.012
Umuahia	288 ± 24	2309 ± 75	992 ± 27	286 ± 16	90 ± 18	15.3 ± 1.4	39.6 ± 10.0	0.014 ± 0.003
	268 – 315	2257 – 2395	763 – 1295	268 – 300	73.0 – 109	14.0 – 17.0	33.5 – 51.1	0.012 – 0.017
	281	2275	919	289	88	16	34.2	0.014
Combined	183 ± 67	2367 ± 160	882 ± 118	274 ± 11	74 ± 20	15.1 ± 1.6	37 ± 7	0.021 ± 0.009
(n = 30)	101 – 315	1985 – 2526	689 – 1295	251 – 301	46.0 – 119	12.0 – 18.3	25 – 54	0.009 – 0.039
	170	2400	880	280	72	15	36	0.02

Note: Walnut moisture content is 7 ±1% (n = 5). Data in this table can be converted to wet weight data by multiplying values of concentrations by 0.93

Variation of metals in walnuts according to sampling sites

The result of one-way ANOVA conducted to check for significant differences among mean metal concentrations in the studied areas showed that sampling areas actually influenced the levels of metals in walnut kernel. PCA was also used to reveal possible spatial variations in the elemental constituents of walnut kernel samples in the study areas (Figures 2). The PCA analysis was based of correlation matrix, and accepted significance level of <0.05 was selected. The probability associated with the Bartlett's test was <0.001, which satisfied the requirement that it should be less than the level of significance [52]. Moreover, loadings <0.5 are considered miserable while loadings >0.9 are typically regarded as excellent. The Kaiser Criterion was employed in choosing the number of components, and only factors with eigenvalues greater than 1 were retained [43].

Table 4 showed the factor loadings, number of significant factors, and total variance (%) that were explained by Varimax with Kaiser normalized rotation method. This rotation method was useful in revealing the interaction of the several elements studied. PCA data revealed that a 3-component solution (varifactors) would be sufficient to explain 75.163% of the total variance (Table 4). The factor loadings illustrated that the first varifactor (factor 1) explained

35.82% of the total variance and loaded heavily on the positively correlated variables, describing Ca, Mg, Cu and Zn (range of loadings: 0.780-0.873). The second varifactor (factor 2) explained 19.96% of the overall variance and was loaded by only two elements. It was positively correlated with Na and Fe (loadings ranging from 0.592-0.920). The third varifactor (factor 3) was loaded primarily by positively correlated K and Pb, which have good loadings of 0.889 and 0.703 respectively. It is however, pertinent to observe that all elements in the varifactors (irrespective of sampling areas) showed positive correlation indicating that they must have emanated from the same source, most likely natural sources only. The interrelationships among the elements in the varifactors space are shown as PCA plots (Figure 2). As observed from the figures, the elements tend to cluster in group. For instance, elements such as Ca-Cu-Zn are linked with the first varifactor.

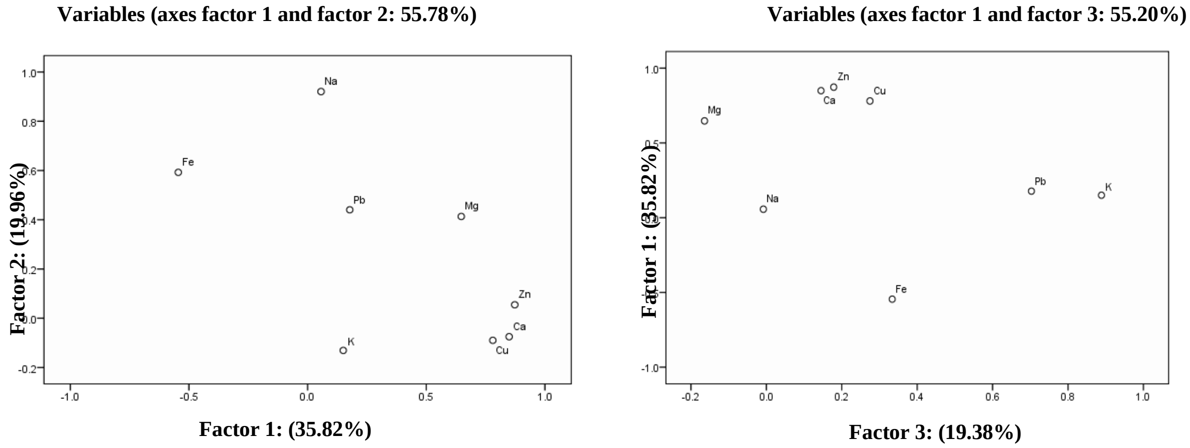

Figure 2. Plots of loadings (after Varimax rotation) based on the concentration of elements in walnut in space of first and second varifactors

Table 4. Factors loading after Varimax normalized rotation

Element	Factor 1	Factor 2	Factor 3
Na	0.057	**0.92**	-0.008
K	0.15	-0.131	**0.889**
Ca	**0.849**	-0.075	0.145
Mg	**0.647**	0.413	-0.164
Fe	-0.545	**0.592**	0.334
Cu	**0.78**	-0.09	0.275
Zn	**0.873**	0.055	0.179
Pb	0.177	0.44	**0.703**
Variability (%)	35.824	19.958	19.381
Cumulative (%)	35.824	55.781	75.163

Notes: Values that appear in bold correspond for each variable to the factor for which the squared cosine is the largest

CONCLUSION

The present study clearly showed the validated results of mineral composition of ready-to-eat cooked *Tetracarpidium conophorum* (Nigerian walnut) kernels. The accurate quantification of these elements becomes very important to the nutrition sciences due to their crucial effect on health. This study showed that the concentrations of K, Ca, Mg, Na, Fe, Zn and Cu were of adequate levels. Pb was also identified but in very low concentrations that would constitute no health concern. The result of one-way ANOVA showed the influence of sampling areas on metal levels. Estimated daily intake of metals from the consumption of walnuts indicated that the consumption of the 68-75 g of walnuts is satisfactory enough to supply the body with these essential minerals without attendant health effects. PCA analysis revealed that elements were of the same source, definitely not of the anthropogenic background. This work contributes to the knowledge of mineral properties of walnut kernel and the results may be useful for the estimation of dietary information.

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