ADEQUACY OF MINERAL CONTENTS OF RAW AND PLAIN STICKY SAUCE OF COMMON AND BUSH OKRA

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ABSTRACT

In Nigeria, common okra (*Abelmoschus esculentus L.)* and bush okra (*Corchorus olitorius L.)* are popular mucilage vegetables used as sticky sauce for easy consumption of starchy staples. Both raw vegetables and sticky sauce of common as well as bush okra were estimated for their potential in the provision of daily dietary allowance of important minerals. Modified methods of the Association of Official Analytical Chemists (AOAC) were used to estimate the assessed minerals. The results showed that the raw and sticky sauce of assessed common and bush okra contained appreciable levels and essential minerals, but are not adequate to meet recommended dietary allowance, except for Fe and Cu. Comparatively, the two species of okra varied significantly in their mineral content of the raw and plain sauce. There was also a negative effect of cooking on the mineral contents, which reduced significantly to an average of 30% on a dry weight basis. Therefore, the two vegetables, either as a fresh or sticky sauce, require additional sources of P, K, Na, Mg, Ca, Mn, and Zn to meet recommended dietary allowance. Furthermore, dried mucilage sauce, though, could be an appreciable post harvest management and storage but not without a loss of about one-third mineral content in the process. However, the sauce of common okra and bush okra are good sources for any of the assessed mineral restricted diets.

- Keywords: bush okra, common okra, mineral content, recommended dietary allowance, sticky sauce -

INTRODUCTION

Vegetables are nutritious foods that provide sufficient amount of nutrients needed for normal body functions, maintenance and reproduction. Also, their intake in different combination is essential for the maintenance of healthy life and normal body function (RUMEZA *et al.*, 2006). Vegetables have a lot of health benefits, which include reduced cancers, diabetes and cardiovascular diseases (COX *et al.*, 2000). Leafy vegetables are major sources of nutrients in rural areas where they contribute substantially to protein, mineral, vitamins, fiber and other nutrients which are usually in short supply in daily diets. Besides their use as food, they also add flavor, variety, taste, color and aesthetic appeal to what would otherwise be a monotonous diet (MEPBA *et al.*, 2002).

Thousands of leafy vegetables abound in Nigeria and are used primarily as food and medicine. These vegetables are diverse in species from different families and orders, and many of which have specific regional or local area of domestication (FAFUNSO and BASSIR, 1987; MEPBA *et al.*, 2007). However, they have crossed regional or local barriers through migration and exchange of goods. Presently, they are being cultivated throughout the country but are concentrated in their domesticated regions or localities. As a consequence, they bear different local names from one region or locality to the other in order of increasing distance. For example, bush okra in the southern part of Nigeria, is known as "ewedu" in Lagos and Ogun state, whereas, it is called, "ooyo" in Osun and Oyo state. Leafy vegetables are seasonal and in abundance shortly after the rainy seasons but become scarce during the dry season. They are sold in many Nigerian markets to meet daily demand as an important complement of staple dishes (FAFUNSO and BASSIR, 1987; MEPBA *et al.*, 2007).

Two of the abundant vegetables in Nigeria are common okra (*Abelmoschus esculentus*) and bush okra (*Corchorus olitorius*); common okra is popularly grown at every nooks and crannies of Nigeria while bush okra is concentrated in southwest Nigeria. Common okra and bush okra are largely cultivated by both men and women for domestic and commercial purposes. Common okra, *Abelmoschus esculentus* (L.) Moench (synonyms, *Hibiscus esculentus* L.), belongs to the family of Malvaceae, and is known as lady's finger in English. It was believed to have originated in south-East Asia and have spread widely in tropical, subtropical and warm temperate regions, but is particularly popular in West Africa (HAMON and SLOTEN, 1995). On the other hand, bush Okra (*Corchorus olitorius* L.) belongs to the family of Tiliaceae, its English name is Jew's mallow. Genetic diversity points to Africa as its first centre of origin (SINGH, 1976**)**. At present, *Corchorus olitorius* has widely spread all over the tropics and probably occurs in all countries of tropical Africa (EDMONDS, 1990). It is a leading leaf vegetable in many African countries such as Côte d'Ivoire, Benin, Cameroon, and Nigeria (SCHIPPERS, 2000).

Common and bush okra are mucilaginous vegetable, both the fruit and leaves of these popular vegetables are used as food in Nigeria. Their young immature fruits are important vegetable, consumed cooked or fried. In Nigeria, they are usually boiled in water to make slimy sticky soups and sauces. The young leaves of common okra are commonly used as spinach and sometimes as cattle feed (BURKILL, 1997) while that of bush okra are more valued as cooked slimy sticky sauce, compared to common okra fruit. In Nigeria, sticky sauces from these two vegetables are found suitable for easy consumption of starchy balls made from cassava, yam or millet (AKORODA, 1988). The very small fruits of common okra can fetch a higher price, being of prime quality while Jew's mallow is a high quality leafy vegetable in market value, consumers' preference and nutritional value. The two vegetables are grown under rain fed conditions, the immature fruits of common okra and fresh leaves of bush okra can be conserved by drying, whole or chopped, or by pickling and sell as dried ground for the preparation of this slimy sauce during the dry season.

Common and bush okra mucilage is suitable for medical and industrial applications. Common okra mucilage has been used as a plasma replacement or a blood volume expander and its leaves are sometimes used as basis for poultices, as an emollient and to treat dysuria. Okra mucilage is added as size to glaze paper and is also used in confectionery. Roasted common okra seeds are used in some areas as a substitute for coffee. Tests conducted in China suggest that an alcohol extract of *Abelmoschus* leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, improve renal function and reduce proteinuria (TOMODA *et al.*, 1980). On the other hand, Jute mallow has been the most widely used packaging fibre for more than 100 years because of its strength and durability, low production costs, ease of manufacturing and availability in large and uniform quantities. In Kenya, the root scrapings of Jew's mallow are used to treat toothache; in Congo, the root decoction is a tonic and leafy twigs is used against heart troubles; in Tanzania, an infusion of the leaves is taken against constipation; while in Nigeria, the seeds are used as a purgative and febrifuge (EDMONDS, 1990; BURKILL, 2000).

Fresh common okra can be transported quite easily in bulk and kept for a few days without much loss of quality. However, Jew's mallow leaves cannot be kept long. Mostly, the product is sold on the harvest day, and it is constantly kept wet. If cooled to 20°C it can be kept for about 1 week, in cold storage for several weeks. If the leaves are dried and pounded to powder, the product can be stored for at least half a year (AKORODA, 1988). Since, both vegetables are prepared as a sticky slim sauce by boiling in water and common okra is considered more stable in quality, then it is assumed that a lesser proportion of its nutrients would be lost through the boiling process when compared to Jew's jute. Therefore, the present study was designed to estimate the mineral content of raw and sticky sauce of common and bush okra for recommended daily dietary intake and to compare mineral nutrient loss during preparation of common okra and bush okra sauce. The study will enhance knowledge on boiled and dried mucilage as a means of post harvest handling and storage for maintaining mineral constituents.

MATERIALS AND METHODS

Samples collection and preparation

Indigenous fresh green moderate size of Common okra fruits and leafy Bush okra samples were purchased from three retailers, as three replicates, in three major markets at Ijebu-Ode (New market, Oke-Aje and Ita-Ale). The samples were transported in properly labeled polythene bags to the Chemistry Laboratory, Tai Solarin University of Education, Ijagun, Ijebu-Ode, Ogun State Nigeria. Twenty grams of wholesome samples were handpicked from each of the common okra and bush okra samples, destalked, rinsed thrice in deionized water, drained, chopped into smaller pieces, and divided into two portions.

Preparation of raw vegetables

The first portions were air dried in an air-circulating oven at 65°C for 5hrs for bush okra samples while common okra was dried for 10 hrs. The dried samples were ground in a sample attrition mill (model no. ED-5), sieved into 4mm particle sizes, kept at 4°C and labeled as R (raw) samples.

Preparation of plain sticky sauce samples

The second portions were further chopped into smaller pieces and boiled for 5 min to slim sticky sauce as usually prepared as complement to stew for consumption of starchy staples in the southwest of Nigeria but without salt and then air dried at 55°C until constant weight was assumed, ground and sieved into 4mm particle sizes and labeled S (sauce) samples.

Assay methods

All chemical Analyses were carried out in triplicates using modified methods of the Association of Official Analytical Chemists (AOAC, 2005). A gram of 4mm particle size of common and bush okra samples were combust at 500°C for 5 hrs in a cool muffle furnace and left overnight to cool to room temperature, the residue was weighed as ash content and kept at 4°C for mineral analysis.

Elemental analysis

A half-gram ash of each sample was, subsequently, digested in 2.5 mL selenium/H_2SO_4 mixture (3.5 g Se/1L H_2SO_4) at 200°C. The residue was re-suspended in selenium/H_2SO_4 mixture; Na, Mg, Ca, and K were determined using Jenway Digital Flame Photometer (PFP7 model), phosphorous by the Vanodo-molybdate method, while Fe, Mn, Cu, and Zn were determined using Buck Scientific Atomic Absorption Spectrophotometer (BUCK 210VGP model).

Statistical analysis

Estimation of precision was measured using the statistical analysis system software package [19]. Detection of variation between vegetables, raw and cooked, and purchased markets for minerals were based on Analysis of variance (ANOVA) using General Linear model (GLM) and useful relationships between minerals were estimated using Pearson correlation analysis, in the same SAS software package.

RESULTS

Mineral levels in raw and sticky sauce of common okra and bush okra

Samples of Nigerian common okra and bush okra by different retailers were obtained from three different major local markets in Ijebu-Ode and were assessed for nine macro and micro minerals in both raw and sticky sauce. The precision measures the nine assessed minerals, across all samples of raw and sticky sauce of common and bush okra as estimated in SAS provided in Table 1. In overall samples, the decreasing order of abundance of minerals were as follows: K>Na>Ca>P>Fe>Mg>Zn>Mn>Cu, with the following mean values on a dry weight basis, 376.03±25.37 mg/100g, 250.2±8.58 mg/100g, 176.73±19.88 mg/100g, 82.11±7.47 mg/100g, 4.23±0.44 mg/100g, 2.91±0.33 mg/100g, 2.39±0.26 mg/100g, 0.88±0.12 mg/100g and 0.75±0.08 mg/100g, respectively. The results indicate the abundance of macro minerals over micro minerals but with a fall in Mg. On a clos-

Table 1 - Descriptive statistics between the raw and boiled common okra and bush okra in Ijebu-Ode.

Variable	Mean mg/100g	SD	SE±	CV	Range	Minimum	Maximum	N
Raw-common Okra								
Sodium	258.77	2.5	1.02	0.97	7	255.1	262.1	9
Potassium	351.32	2.4	0.98	0.68	6.5	347.9	354.4	9
Calcium	95.42	2.28	0.93	2.39	5.7	92.4	98.1	9
Phosphorus	60.32	2.3	0.94	3.82	5.9	57.2	63.1	9
Iron	4.24	0.99	0.4	23.25	2.21	3.1	5.31	9
Zinc	2.67	0.99	0.4	36.93	2.23	1.52	3.75	9
Magnesium	2.48	0.72	0.3	29.12	1.62	1.74	3.36	9
Manganese	0.87	0.5	0.2	57.4	1.08	0.42	1.5	9
Copper	1.05	0.21	0.08	19.76	0.48	0.78	1.26	9
Sauce-common Okra								
Sodium	223.17	2.32	0.95	1.04	6	220	226	9
Potassium	235.17	2.79	1.14	1.19	8	231	239	9
Calcium	87.67	2.25	0.92	2.57	5.2	84.9	90.1	9
Phosphorus	47.94	2.32	0.95	4.85	6.05	44.75	50.8	9
Iron	2.1	0.99	0.4	46.96	2.23	0.95	3.18	9
Zinc	1.56	0.99	0.4	63.08	2.28	0.39	2.67	9
Magnesium	1.32	0.72	0.3	54.64	1.62	0.58	2.2	9
Manganese	0.63	0.5	0.2	79.17	1.1	0.17	1.27	9
Copper	0.67	0.21	0.08	31.11	0.47	0.4	0.87	9
Raw-bush okra								
Sodium	278.17	2.79	1.14	1	8	274	282	9
Potassium	487.52	2.4	0.98	0.49	6.5	484.1	490.6	9
Calcium	289.62	2.33	0.95	0.8	6.1	286.4	292.5	9
Phosphorus	127.27	2.25	0.92	1.77	5.2	124.5	129.7	9
Iron	7	1	0.41	14.21	2.46	5.74	8.2	9
Zinc	3.39	0.99	0.4	29.13	2.31	2.2	4.51	9
Magnesium	4.99	0.72	0.3	14.48	1.62	4.25	5.87	9
Manganese	1.43	0.5	0.2	35.12	1.11	0.96	2.07	9
Copper	0.7	0.19	0.09	27.27	0.48	0.38	0.86	9
Sauce-bush okra								
Sodium	264.87	2.46	1	0.93	6.8	261.3	268.1	9
Potassium	457.57	2.61	1.06	0.57	7.4	453.7	461.1	9
Calcium	234.92	2.58	1.05	1.1	7.3	231.1	238.4	9
Phosphorus	96.94	2.32	0.95	2.4	6.05	93.75	99.8	9
Iron	3.55	0.99	0.4	27.77	2.23	2.4	4.63	9
Zinc	1.98	0.99	0.4	49.75	2.3	0.8	3.1	9
Magnesium	2.8	0.72	0.3	25.84	1.63	2.05	3.68	9
Manganese	0.6	0.5	0.2	83.83	1.11	0.13	1.24	9
Copper	0.46	0.21	0.08	44.88	0.46	0.2	0.66	9

SD, standard deviation; SE, standard error; CV, coefficient of variation.

er observation made from the visualized bar graphs, levels of minerals were higher in both raw and sticky sauce of bush okra than common okra except Cu for raw, Mn and Fe for cooked. Levels of all the minerals in the two vegetables were reduced upon boiling (Fig. 1). Based on simple calculations of the estimates obtained in SAS, Common okra lost more of Na, K, Mg, and Cu on cooking than bush okra while the latter lost more of P, Ca and Mn than the former but both lost almost the same amount of Fe and Zn**.** The minimum estimated loss in common okra on cooking and drying was 8.12% for Ca and the maximum was 50.49% for Fe with a mean loss of 30.91% while for bush okra, the loss ranged from 4.78% for Na to 58.10% for Mn with a mean loss of 30.63%. The difference in the overall loss in minerals from the two vegetables could be considered small and insignificant. Therefore, one third of the minerals are lost in the cooking and drying process when packaged as a post harvest handling or

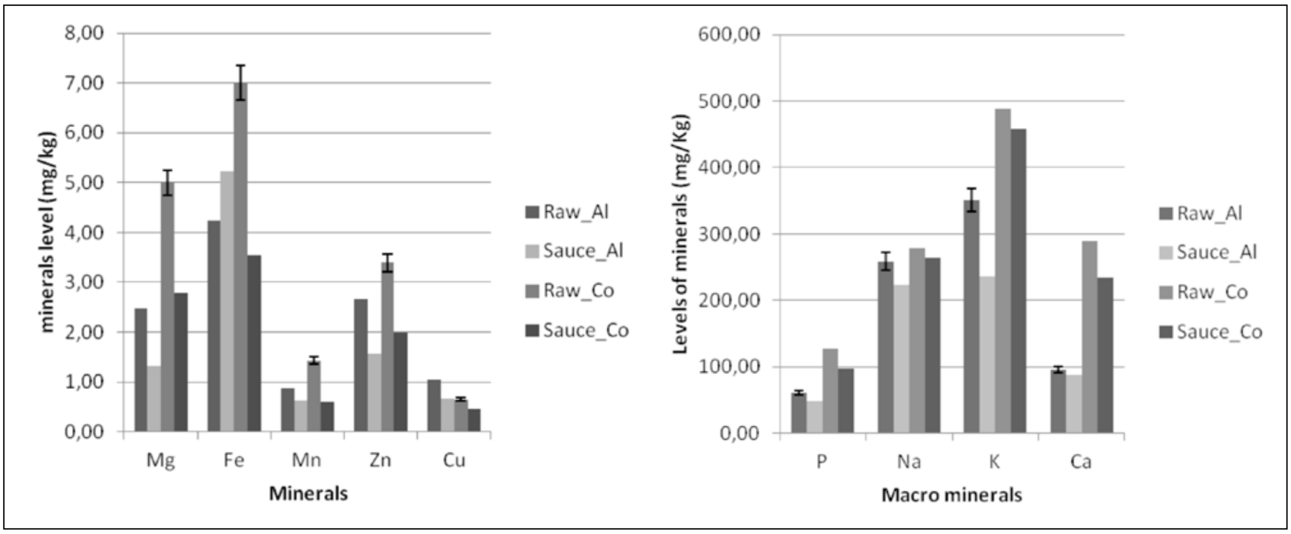

Fig. 1 - Trends of minerals levels in raw and sauce of common and bush okra on dry weight basis.
Raw_Al, raw common okra; Sauce_Al, common okra sauce; Raw_Co, raw bush okra; Sauce_Co, bush okra sauce.

management for later use as slimy sauce. The trend in mineral loss per vegetable in cooking is provided in Fig. 2.

Interaction of vegetable type, purchased market and cooking on mineral content

Analysis of variance (ANOVA) based on General Linear Model (GLM) in the same SAS package, in overall, showed a very large variation in all the assessed minerals ($P<0.0005$) but less variation was observed for Cu ($P<0.005$) and Zn ($P< 0.05$) while Mn was not significantly varied. The variations observed in the nutrients were highly contributed by the differences in the vegetable type and raw/cooking (processing). However, only raw/cooking contributes to the variation observed in Zn. Manganese, though, not generally significant but was significantly varied between raw or cooked vegetable. Therefore, there was a significant difference between common okra and bush okra for Na, P, K, Ca, Mg, Fe, and Cu but no significance difference was observed between the two vegetables for Zn and Mn. The results also showed that cooking has a significantly negative effect on the levels of all the minerals assessed, that is, the levels of minerals reduced on cooking. Effect of market was also tested for only the three micro minerals; Zn, Mn and Cu were significantly varied while the rest were not. Duncan multiple grouping provides a visual variation of the nutrients between the vegetables, raw/boiled, and markets, based on the significant difference between their means, by assigning them into groups using letters A, B and C. A detailed ANOVA measures and Duncan grouping were also given in Table 2.

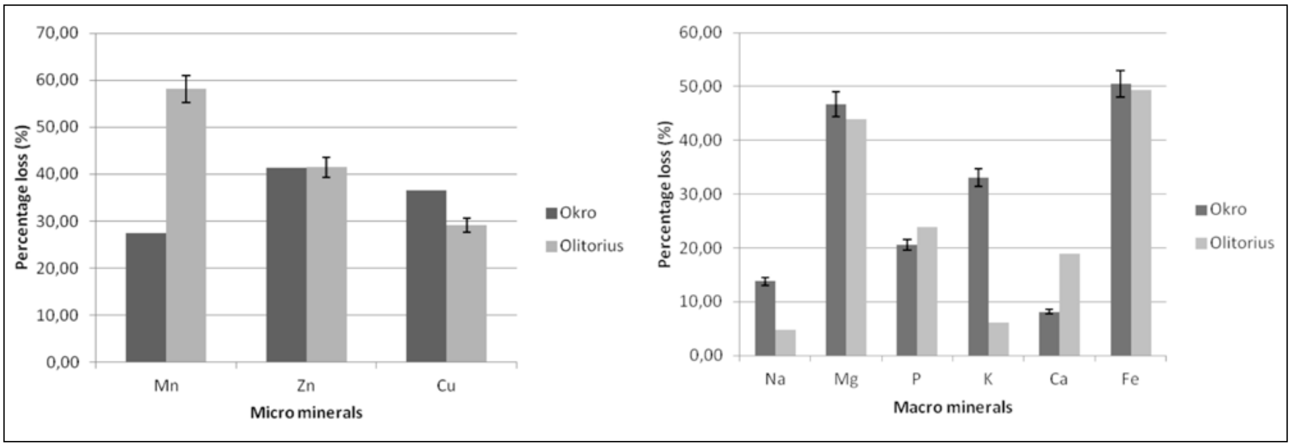

Fig. 2 - Proportion of mineral loss by common okra and bush okra upon cooking at 100°C for 5 min Okro, common okra; Olitorius, bush okra.

Table 2 - Effect of Species type, cooking and purchased market on mineral levels based on GLM-ANOVA.

	Model					Species		Raw/Sauce		Market	
	Mean	CV	SS	R^2	Pr>F	Pr>F	SS	Pr>F	SS	Pr>F	SS
Macro-mineral mg/100g											
Na	256.24	2.58	9187.47	0.91	***	***	5599.81	***	3586.81	ns	101.3
K	382.89	6.20	224919	0.95	***	***	192890	****	32017	ns	101.3
P	83.12	6.5	22901	0.97	***	***	20168	***	2734	ns	101.3
Ca	176.9	7.83	180737	0.98	***	***	174882	***	5850	ns	101.3
Mg	2.9	26.78	40.70	0.77	***	***	23.32	***	16.88	ns	10.45
Micro-minerals											
Fe	4.22	24.39	73.62	0.77	***	**	26.65	***	46.96	ns	19.41
Cu	0.70	30.27	1.04	0.53	**	**	0.55	*	0.50	**	0.85
Mn	0.88	59.64	2.12	0.27	ns	ns	0.40	*	1.71	***	5.02
Zn	2.4	41.22	11.4	0.37	*	ns	1.94	**	9.45	***	19.41

Duncan Grouping	Na	K	Ca	P	Mg	Mn	Fe	Zn	Cu
By Species									
CommonOkra	B	B	B	B	B	A	B	A	A
bush okra	A	A	A	A	A	A	A	A	B
By Process									
Raw	A	A	A	A	A	A	A	A	A
Sauce	B	B	B	B	B	B	B	B	B

ns, not significant; *, P<0.05; **, P<0.005; ***, P<0.0005, SS, sum of square.
Means with the same letter are not significantly different.

Table 3 - Correlation Matrix among the minerals based on Pearson model.
Veg_C is degree of common consumption (okra<ewedu), Proc_C, raw to cooking Vice versa.

	Proc_C	Na	K	Ca	P	Fe	Zn	Mg	Mn	Cu
Veg_C	ns	0.74***	0.90***	0.97***	0.92***	0.50*	ns	0.65**	ns	-0.46*
Proc_C	1	-0.58**	ns	ns	ns	-0.68***	-0.53**	-0.54**	-0.46*	-0..56**
Na		1	0.95***	0.79***	0.86***	0.74***	0.45*	0.77***	0.42*	ns
K			1	0.91***	0.93***	0.68***	ns	0.76***	ns	ns
Ca				1	0.98***	0.63**	ns	0.76***	ns	ns
P					1	0.72***	ns	0.82***	0.43*	ns
Fe						1	0.89***	0.97***	ns	ns
Zn							1	0.83***	ns	ns
Mg								1	ns	ns
Mn									1	ns

ns, not significant; *, P<0.05; **, P<0.005; ***, P<0.0005.

Relationship among minerals

Pearson correlation analysis was used to identify useful associations among the nutrients. The matrix generated (Table 3) revealed that Na was strongly significantly correlated with all the other macro minerals (P<0.0005) and Fe but slightly with Zn and Mn. Therefore, as the level of Na increases, the level of all P, Ca, K, Mg, Fe, Zn and Mn also increases and vice-versa. Potassium and calcium were independently correlated with all the macro minerals and Fe but both were insignificant with the rest of micro minerals. Therefore, as levels of K and Ca increases, level of other macro minerals and Fe increases. A strong positive relationship was observed among Fe, Zn and Mg (P<0.005). Manganese on the other hand was correlated with only Na and P while Cu had no relationship with any of the minerals. The correlation matrix also showed that the levels of the minerals were higher in bush okra than common okra except Cu that was inversely correlated while Zn and Mn were insignificant. In addition, the levels of minerals were observed to be inversely correlated with cooking except that of P, K and Ca. Therefore, cooking reduces the level of these minerals in the assessed vegetables, thereby supporting the results obtained from ANOVA.

DISCUSSION

Adequacy of the Minerals in Common and bush okra

The adequacy of mineral content for estimated average requirements (EAR) and recommended daily allowance / adequate intake (RDA/AI) in both the raw and sticky sauce of common and bush okra per hundred grams were judged using DRIs (DRIs, 2004). The mean levels of potassium (235.51 - 487.52 mg/100g) and sodium (223.17 - 278.17 mg/100g) estimated in the raw and sticky sauce of both common okra and bush okra were too low to meet the RDA/AI for K (4700 mg) and Na (1500 mg). Therefore, the content of sodium in both the raw and sauce of common bush (223.2 - 258.8 mg/100g) and bush okra (264.9 - 278.1 mg/100g) is considered safe due to health impairments such as increased urinary calcium loss and hypertension that could result from excess intake of sodium (WARDLAW and KESSEL, 2002). Since, cooking reduces Na level, then, common okra and bush okra sauces are good in restricted Na diets. Neither the raw nor the sauce of the two vegetables could also provide the daily EAR of calcium (800 mg), although bush okra could provide about 30% estimated average requirement (800 mg) while common bush Okra could only provide about 11%. Therefore, additional supplementary sources of Ca such as fortified cereal and condensed cow's milk (USDA, 2010) were required in the walnut diets. The magnesium level, either in the raw or sauce of the two vegetables (0.67 - 4.99 mg/100g) were too low for any Mg provision in the body when compared with the daily EAR of 330 mg. So, the phosphorus content of the two vegetables (48 - 127 mg/100 g) was also inadequate to provide for 580 mg EAR. Estimated average requirements for Mn is yet to be evaluated but the RDA/AI is 2.3 mg and each of the raw vegetable and sauce could provide an approximately proportion of 25% of the allowance except for 1.43 mg obtained in raw bush okra that could provide about 62%. Both the raw of common okra (1.05 mg/100 g) and bush okra (0.7 mg/100 g) had an adequate EAR content of Cu (700 ug) while their sauce had a proportion of 96 and 66%, respectively. However, raw common okra contains Cu level that is slightly higher than the 900 ug RDA but lower than tolerable upper limit level of 10000 ug, [20], which is reduced upon cooking by 36% (0.67 g) and therefore posed, no health hazard. None of the vegetables, either raw or cooked sauce could meet the daily average requirement and allowance for Zn intake of 9.4 and 11 mg, respectively. Only the raw bush okra met the estimated average requirement of Fe (6 mg), which is 77.7% of daily allowance intake (8 mg) but was reduced upon cooking by 34%, providing about 76.5% EAR while raw common okra could provide for 70.1% EAR, which was also reduced upon cooking by 30%. In overall, plain sauce of these vegetables contains appreciable levels of minerals assessed but did not meet the daily dietary allowance of these minerals except for Cu and Fe. Therefore, the sauce should be taken to complement carbohydrate based meal or soup supplement that contains additional sources of minerals or should be made into a proper soup with top sources of minerals for provision of adequate daily dietary intake of these minerals for health implications.

Interaction of species, cooking and market on mineral levels

Boiling was observed to reduce all the mineral contents in both the common and bush okra with a variation between the two okra vegetables, common okra lost more in macro minerals than bush okra (except in Ca and K) while bush okra lost more of micro minerals. By simple estimation, based on average, about one-third of the mineral content was lost on dry weight basis, when considered for use as a mucilage sticky sauce after boiling. Similar loss due to boiling was reported in both common and bush okra and many other vegetables (MEPBA *et al.*, 2002; AUTA *et al.*, 2011; AYE, 2012; YAKUBU *et al.*, 2012; ILELABOYE *et al.*, 2013). There are also reports on species differences for loss in minerals as presently observed (MEPBA *et al.*, 2002, ILELABOYE *et al.*, 2013; SHAHNAZ *et al.*, 2003). Varying degree of mineral loss due to cooking / boiling were reported in similar studies, a proportion of 6 to 30% mineral loss (ILELABOYE *et al.*, 2013), 25 to 55% (AYE, 2012) and 30 to 54% (YAKUBU *et al.*, 2003). In addition, SHAHNAZ *et al.* (2003) reported a pronounced effect of peeling combined with cooking on mineral loss of some vegetables (14 to 74%). The mineral loss in the present study ranged between 4.0%, for Na in common okra, to 58%, for Mn in bush okra, which is comparable to the previous reported losses. The differences in ranges reported could be largely due to differences in species type, region, analytical methods, varying degree of cooking time and temperature. Whatsoever, there is loss of minerals due to either boiling or cooking, which is as a result of mineral leaches from the vegetables into the cooking water during the process. Most of the proteins that contain the inorganic elements such as prosthetic groups are denatured during the process with loss of these minerals into the boiling water. Market effect was limited to three micro minerals, Mn, Cu and Zn which could be attributed to diverse agricultural practices from different sources, soil fertility, environments and use of fertilizers. Similar useful associations obtained among the minerals have earlier been observed in food crops. The strong association obtained between Fe and Zn in the present study corroborates that of similar studies in plants (BEEBE *et al.*, 2000; SILVA *et al.*, 2012).

CONCLUSIONS

The study detected appreciable levels of P, Na, Mg, K, Ca, Fe, Mn, Cu, and Zn in both common and bush okra per 100g which were reduced upon cooking at 90-100°C for 5 min. The two species differed widely in their levels of mineral content in both raw vegetable and sticky sauce. They also lost specific mineral on cooking at different proportion but had an overall equal proportion of a mean percent loss. There was also an influence of market differences on Cu Mn and Zn. Dried mucilage as a postharvest management for later use such as sticky sauce reduced the mineral content by a mean proportion of about 30%. Plain soup of these vegetables either fresh or after storage requires additional sources of these minerals, except Fe and Cu, to meet recommended daily intake but are good sources for Na and any of these minerals restricted diets.

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