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Technology

Mineral Components Important for Health from Animal Sources

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Animal samples include two different types of snakes, frog and five different types of fishes. The flesh, bones, scales and heads of the animals were separated and analysed for moisture, ash and minerals. The minerals, were not detected from any sample. Cu, Cd, Pb, Co and Cr. The moisture content was generally low. The ash was consistently highest in the bone but consistently lowest in flesh among the fish and in the scale among the snakes. The concentration of the minerals was highly varied among the body parts. The Ca/P ratios ranged from excellent to poor. The Na/K ratios were generally on the high side ranging between 0.55-1.05. The mineral safety index was generally good for Na, P, Mg and Ca, poor for Fe but very bad for Zn. It is an indication that the samples were contaminated by Fe and Zn.

Key words: Animal samples, Ca/P and Na/K ratios, Mineral safety index.

Introduction

Nigeria is predominantly an agricultural country although there is an active petrochemical industry in the Niger Delta area and industrial development is expanding, particularly in the south (Welcome 1979). Heavy urbanization along coastal rivers and lagoons, and intensive agriculture for cash crops in some other parts of the country, may give rise to local pollution problems.

Fish, an important source of animal protein of high biological value, vitamins A and D, and also contain several minerals such as Ca, Fe, Cd, Pb, etc., which may be beneficial or toxic to man depending on the exposure level (Bowen 1979; Mudambi and Rajagopal 1981). Fish is in increasing demand in Nigeria due to high population growth rate, increasing national income and increasing cost of meat and other sources of animal protein (Adeyeye 1997). The relatively high per caput consumption of fish has been attributed to greater availability of this product at relatively cheaper prices (Osajuyigbe 1981). Currently, about 40% of animal protein consumed in the country is derived from fish.

Biological magnification could lead to toxic levels of minerals in fish, even when the exposure is low. The proven toxicity of high concentrations of heavy metals in water to fishery and wild life (Cain *et al* 1980) poses the problem of an ultimate disequilibrium in the natural ecological balance. Apart from destablishing the ecosystem, the accumulation of these toxic metals in the aquatic food organisms is a potent threat to public health. The Minamata Bay epidemics remains a classic example (Goldwater 1971; Laws 1981).

Some reports have been published on the correlation between minerals in fish and their environment (Okoye 1991; Ipinmoroti and Oshodi 1993; Adeyeye 1994). The health implications of the mineral distribution in the fish samples have not been seriously emphasized. In the current report, minerals were determined in five different types of fishes, an amphibian and two types of snakes. The flesh, heads, bones and scales of all the animals were separated appropriately before each part was analysed. This separation was necessary because when fish is roasted or smoke dried (as these samples) head, flesh and bone become soft enough for easy consumption. While it is only the flesh, scales and bone that can be consumed in the snakes but not the head. Based on the mineral composition results, the following parameters were further calculated: calcium/phosphorus (Ca/P) and sodium/potassium (Na/K) ratios and mineral safety index (MSI) of the various sample parts.

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Materials and Methods

The samples of animal were purchased from the Oba market (Ado-Ekiti, Ekiti State, Nigeria) in dry form. The samples were identified and each sample was divided into head, flesh, bone and scales as appropriate. Part of every sample were homogenized in Kenwood major blender, packed in labeled plastic containers and stored in the laboratory refrigerator for pending analysis. Analyses were carried out without further processing.

Determination of moisture and ash. Between 0.5217g-0.6275g of samples were weighed for moisture content determination and dry ashing (AOAC 1990). Samples were dried at 105°C until constant weight while ashing was carried out at a temperature of 540°C in the furnace (NEY M-525) to constant weight.

Determination of minerals. Each ashed sample was transferred into a 50 ml beaker, crucible was washed with 25 ml, 20% (v/v) nitric acid into corresponding beaker and then heated the beaker to boiling to break the ash. The solution was carefully filtered and transferred into 50 ml standard volumetric flask and made up to the mark with distilled de-ionised water (AOAC 1990). The phosphorus was determined colorimetrically by Spectronic 20 (Gallankamp UK) as described by Pearson (1976). Cu, Cd, Fe, Pb, Co., Zn, Cr, Mg and Ca were determined using a Perkin Elmer model 306 Atomic Absorption Spectrophotometer, while Na and K were determined using a flame photometer (Corning, UK, Model 405). All determinations were in duplicate. Earlier, the detection limits of the metals had been determined using the methods of Varian (1975). The optimum analytical range was 0.1 - 0.5 absorbance units with a coefficient of variation of 0.87% - 2.20%. All chemicals used were of analytical grade (BDH, London). Both the moisture and ash contents were reported as g/100g while all the minerals were reported as mg/100g.

Statistical analyses. Calcium/phosphorus (Ca/P) and sodium/potassium (Na/K) ratios were calculated for all the samples (Nieman *et al* 1992) and mineral safety index (MSI) (Hathcock 1985) as appropriate. The differences between the standard mineral safety index and the mineral safety index of the samples were also calculated. Mean standard deviation and coefficients of variation percent were also calculated where appropriate (Steel and Torrie 1960).

Results and Discussion

The scientific and vernacular names as well as the body parts used in the analyses are all shown in Table 1. The heads of the snakes were not analysed because they are normally not consumed as food. The other parts analysed can be consumed although the part consumed can depend on an individual choice.

Table 2 depicts the moisture content of the various samples. Only sample E_3 had a high moisture content of 39.10g/100g, this might be due to the fact that the drying process had not been completed. All other samples had low moisture content values, this would ensure a fairly long keeping quality for the samples. This is a good advantage because frequent electricity failure is rampant here. The ash content of the samples is depicted in Table 2. The ash content of any sample is an indication of its mineral content. In all the samples, the bones (A_2, B_2, C_2, D_2, E_2, F_2, G_2, and H_2) were consistently highest in their ash levels; while scales had the lowest levels of ash in snakes (A_3 and B_3), the flesh had the lowest levels among the other aquatic samples (C_1, D_1, E_1, F_1, G_1, and H_1). The high ash values in the bones were consistent with the high ash levels in the cheliped, thoracic sterna and small thoracic appendages of the male and female samples of fresh water crab *(Sudananautes africanus africanus)* (Adeyeye 2002).

Table 1
Scientific and vernacular names of the animal samples

Animal sample	Animal part	Sample number	Vernacular name (Y)[a]	English name	Systematic name
Snake	Flesh	A_1	*Oworu*	Cobra	*Serpentes ophidia*
	Bone	A_2	"	"	"
	Scales	A_3	"	"	"
	Flesh	B_1	*Ogbara*	Wart	*Channa obscura*
	Bone	B_2	"	"	"
	Scales	B_3	"	"	"
Frog	Flesh	C_1	*Konko*	African bull frog	*Rana adspersa*
	Bone	C_2	"	"	"
	Head	C_3	"	"	"
Fish	Flesh	D_1	*Abo*	Sole	*Cynoglossus senegalensis*
	Bone	D_2	"	"	"
	Head	D_3	"	"	"
	Scales	D_4	"	"	"
	Flesh	E_1	*Kalamu*	Fresh water sardine	*Pellonula afzeliusi*
	Bone	E_2	"	"	"
	Head	E_3	"	"	"
	Flesh	F_1	*Doje*	Silver fish	*Notopterus ater*
	Bone	F_2	"	"	"
	Head	F_3	"	"	"
	Scales	F_4	"	"	"
	Flesh	G_1	*Epiya*	Tilapia	*Oreochromis niloticus*
	Bone	G_2	"	"	"
	Head	G_3	"	"	"
	Flesh	H_1	*Abori*	Mudfish	*Clarias anguillaris*
	Bone	H_2	"	"	"
	Head	H_3	"	"	"

[a]Y, Yoruba.

The mineral elements analysed for are also depicted in Table 2. The minerals were not detected in the samples are Cu, Cd, Pb, Co and Cr while Fe was not detected in D_4 and G_2, also Zn was not detected in D_4. It is gratifying that both Pb and Cd were not detected in any of the samples since both metals are not needed in the body for any biochemical process. In literature, the values of Pb in *Illisha africana* fish from fresh water ponds ranged between 0.56-2.52ppm in various body parts on dry weight basis (Adeyeye 1993), while the values in fresh, lagoon and sea water fish samples ranged from 0.000 - 0.151ppm

Table 2
Moisture, ash and mineral contents of the various samples

g/100g			Minerals (mg/100g)											
Sample	Moisture	Ash	Cu	Cd	Fe	Pb	Co	Zn	Cr	Na	K	Mg	Ca	P
A_1	7.8	11.6	ND[a]	ND	8.4	ND	ND	30.2	ND	40.2	53.0	38.3	4.7	106.3
A_2	7.4	67.0	ND	ND	6.8	ND	ND	54.5	ND	16.5	16.8	12.9	14.8	3.0
A_3	5.0	2.4	ND	ND	25.7	ND	ND	45.8	ND	158.2	290.0	115.1	158.1	405.3
B_1	10.3	9.5	ND	ND	10.3	ND	ND	54.9	ND	15.5	16.7	14.5	9.4	28.6
B_2	7.6	40.1	ND	ND	6.3	ND	ND	59.7	ND	12.6	19.2	15.3	15.8	3.2
B_3	2.2	5.2	ND	ND	37.0	ND	ND	49.1	ND	116.7	170.9	61.6	125.5	354.2
C_1	6.8	8.0	ND	ND	11.4	ND	ND	31.7	ND	17.9	22.5	16.1	17.1	18.0
C_2	5.8	57.0	ND	ND	6.2	ND	ND	31.1	ND	37.7	60.6	50.1	34.5	10.4
C_3	4.6	32.8	ND	ND	5.0	ND	ND	35.6	ND	22.4	29.4	25.2	19.7	74.1
D_1	10.7	8.7	ND	ND	5.2	ND	ND	17.4	ND	21.6	21.2	16.3	14.2	36.4
D_2	2.4	47.6	ND	ND	22.7	ND	ND	47.4	ND	220.5	323.0	242.9	193.2	33.2
D_3	6.9	23.3	ND	ND	7.7	ND	ND	15.9	ND	78.6	92.7	82.5	53.3	128.5
D_4	9.0	26.1	ND	ND	ND	ND	ND	ND	ND	784.0	950.0	821.7	558.2	1711.8
E_1	11.0	7.2	ND	ND	5.3	ND	ND	24.0	ND	14.5	20.3	16.8	10.1	25.2
E_2	6.2	57.8	ND	ND	5.7	ND	ND	38.8	ND	94.8	120.7	97.1	97.3	20.5
E_3	39.1	33.6	ND	ND	11.6	ND	ND	43.9	ND	42.1	40.1	38.7	32.7	104.9
F_1	10.3	8.5	ND	ND	4.5	ND	ND	10.8	ND	11.2	16.5	12.8	128.0	15.0
F_2	1.5	50.4	ND	ND	7.5	ND	ND	83.5	ND	196.7	191.8	150.1	136.6	28.8
F_3	2.8	25.5	ND	ND	4.6	ND	ND	39.6	ND	147.8	147.8	122.2	90.1	132.5
F_4	0.4	18.4	ND	ND	37.2	ND	ND	57.4	ND	346.3	442.1	3.9	429.4	605.0
G_1	8.9	9.7	ND	ND	7.7	ND	ND	19.2	ND	23.9	34.3	29.2	34.7	57.1
G_2	0.2	53.4	ND	ND	ND	ND	ND	36.6	ND	229.4	384.7	289.2	158.2	907.7
G_3	4.7	45.5	ND	ND	9.4	ND	ND	30.7	ND	41.5	49.4	48.5	39.5	141.4
H_1	10.1	5.0	ND	ND	8.4	ND	ND	26.9	ND	28.8	35.5	28.6	31.5	14.7
H_2	6.1	43.5	ND	ND	11.0	ND	ND	46.4	ND	94.1	116.1	110.8	102.0	24.0
H_3	12.1	16.5	ND	ND	7.9	ND	ND	26.6	ND	37.3	43.2	34.3	33.6	95.2

ND[a], not detected.

in various parts on wet weight basis (Odukoya and Ajayi 1987). The corresponding Cd values in the references were 0.10 - 0.34 ppm (Adeyeye 1993) and 0.000- 0.857ppm (Odukoya and Ajayi 1987). This means that the current samples were safer from these two metals.

It is well-known (Buss and Robertson 1976; Mertz 1981; Oshodi and Ipinmoroti 1990; Fagbemi and Oshodi 1991) that mineral elements are necessary for life. Major role of iron is in the formation of haemoglobin. Fe was highest in their group for A_3 (25.67mg/100g), B_3 (37.04mg/100g) and F_4 (37.23mg/100g) which were in all scales but ND was recorded for another scale sample (D_4). Half of the iron in meat is present as haeme iron (in haemoglobin). This is well-absorbed, about 15 -35%, a figure that can be contrasted with other forms of iron, such as that from plant foods, at 1-10% (Bender 1992). Not only is the iron of meat well absorbed but it enhances the absorption of iron from other sources for example, the addition of meat to a legume/cereal diet can double the amout of rion absorbed and so contribute significantly to the prevention of anaemia, which is so wide-spread in developing countries like Nigeria (Wheby 1974; Bender 1992). Iron facilitates the oxidation of carbohydrates, proteins and fats. Many of the samples are good sources of iron.

Zinc was widely distributed among the samples except in D_4 where ND was recorded. Zinc is present in all tissues of the body and is a component of more than 50 enzymes (Bender 1992). Meat is the richest source of zinc in the diet and supplies one third to one half of the total zinc intake of meat eaters. Zinc dietary deficiency has been found in adolescent boys in the Middle East eating a poor diet based largely on unleavened bread (Bender 1992). Families and individuals who may be using vegetable and cereal sources of protein be-

Table 3
Ratios of Na/K and Ca/P; mineral safety index of Na, Mg, P, Ca, Fe and Zn for the various samples

	Ratio		Mineral Safety Index																	
			Na			Mg			P			Ca			Fe			Zn		
Sample	Na/K	Ca/P	TV[a]	CV[b]	D[c]	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
A_1	0.8	0.04	4.8	0.4	4.4	15	1.4	13.6	10	0.9	9.2	10	0.04	10.0	6.7	3.7	3.0	33	66.4	-33.4
A_2	1.0	5.0	4.8	0.2	4.6	15	0.5	14.5	10	0.02	10.0	10	0.12	29.9	6.7	3.0	3.7	33	119.8	-86.8
A_3	0.6	0.4	4.8	1.5	3.3	15	4.3	10.7	10	3.2	6.8	10	1.3	8.7	6.7	11.5	-4.8	33	100.8	-67.8
B_1	0.9	0.3	4.8	0.14	4.7	15	0.5	14.5	10	0.2	9.8	10	0.1	9.9	6.7	4.6	2.1	33	120.7	-87.7
B_2	0.7	4.9	4.8	0.12	4.7	15	0.6	14.4	10	0.03	10.0	10	0.13	9.9	6.7	2.6	4.1	33	131.3	-98.3
B_3	0.7	0.4	4.8	1.1	3.7	15	1.1	13.7	10	2.8	7.2	10	1.0	9.0	6.7	16.6	-9.9	33	108.1	-75.1
C_1	0.8	0.9	4.8	0.2	4.6	15	0.6	14.4	10	0.14	9.9	10	0.14	9.9	6.7	5.1	1.6	33	69.8	-36.8
C_2	0.6	3.3	4.8	0.4	4.4	15	1.9	13.1	10	0.1	9.9	10	0.3	9.7	6.7	2.8	3.9	33	68.4	-35.4
C_3	0.8	0.3	4.8	0.2	4.6	15	0.9	14.1	10	0.6	9.4	10	0.2	9.8	6.7	2.3	4.5	33	78.4	-45.4
D_1	1.0	0.4	4.8	0.2	4.6	15	0.6	14.4	10	0.3	9.7	10	0.12	29.9	6.7	2.3	4.4	33	38.4	-5.4
D_2	0.7	5.8	4.8	2.1	2.7	15	9.1	5.9	10	0.3	9.7	10	1.6	8.4	6.7	10.1	-3.4	33	104.2	-71.2
D_3	0.9	0.4	4.8	0.8	4.1	15	3.1	11.9	10	1.0	8.9	10	0.4	9.6	6.7	3.4	3.3	33	34.0	-2.0
D_4	0.8	0.3	4.8	7.5	-2.7	15	30.8	15.8	10	13.7	-3.7	10	4.7	5.4	6.7	-*	-	33	-	-
E_1	0.7	0.4	4.8	0.14	4.7	15	0.6	4.4	10	0.8	9.8	10	0.1	9.9	6.7	2.4	4.3	33	52.0	-19.0
E_2	0.8	4.7	4.8	0.9	3.9	15	3.6	1.4	10	0.2	9.8	10	0.8	9.2	6.7	2.6	4.1	33	85.3	-52.3
E_3	1.1	0.3	4.8	0.4	4.4	15	1.4	3.6	10	0.8	9.2	10	0.3	9.7	6.7	5.2	1.5	33	96.6	-63.6
F_1	0.7	81.7	4.8	0.1	4.7	10	0.5	4.5	10	0.1	9.9	10	10.2	-0.2	6.7	2.0	4.7	33	23.7	9.3
F_2	1.0	4.7	4.8	1.9	2.9	15	5.6	9.4	10	0.3	9.8	10	1.1	8.9	6.7	3.3	3.4	33	183.7	-150.7
F_3	1.0	0.7	4.8	1.4	3.4	15	4.6	10.4	10	1.1	8.9	10	0.8	9.3	6.7	2.0	4.7	33	87.0	-54.0
F_4	0.8	0.7	4.8	3.3	1.5	15	0.1	14.9	10	4.8	5.2	10	3.6	6.4	6.7	16.6	-9.9	33	126.3	-93.3
G_1	0.7	0.6	4.8	0.2	4.6	15	1.1	13.9	10	0.5	9.5	10	0.3	9.7	6.7	3.4	3.3	33	42.1	-9.1
G_2	0.6	0.2	4.8	2.2	2.6	15	10.8	4.2	10	7.3	2.7	10	1.3	8.7	6.7	-	-	33	80.5	-47.5
G_3	0.8	0.3	4.8	0.4	4.4	15	1.8	13.2	10	1.1	8.9	10	0.3	9.7	6.7	4.2	2.5	33	67.6	-34.6
H_1	0.8	2.1	4.8	0.3	4.5	15	1.1	13.9	10	0.1	9.9	10	0.3	9.7	6.7	3.7	3.0	33	59.1	-26.1
H_2	0.8	4.3	4.8	0.9	3.9	15	4.2	10.8	10	0.2	9.8	10	0.8	9.2	6.7	4.9	1.8	33	102.0	-69.0
H_3	0.9	0.4	4.8	0.4	4.4	15	1.3	13.7	10	0.8	9.3	10	0.3	9.7	6.7	3.5	3.2	33	58.6	-25.6

[a]TV, Table value; [b]CV, Calculated sample value; [c]D, Difference in value; *-, Not calculated.

cause of low incomes or as an attempt to cope with inflation may not be able to meet the zinc allowances (about 15-20mg) per day. The zinc in these sources is not available as in animal sources (NAS 1971).

The animal samples were good sources of magnesium, sodium and potassium. The sodium and potassium levels here were lower than the levels in *Cyprinus carpio* and *Clarias gariepinus* fish (Adeyeye 1996) and also lower (together with magnesium) than in three different types of land snails consumed in Nigeria (Adeyeye 1996). Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Shils 1973; Shils and Young 1988). Potassium is primarily an intracellular cation, mostly this cation is bound to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrium (Sandstead 1967).

The calcium levels were reasonably distributed among the samples. They were particularly high in the scales followed by the bones. This meant these samples could serve as good sources of the element. Calcium, in conjunction with phosphorus, magnesium, manganese, vitamins A, C and D, chlorine and protein, are involved in bone formation but calcium is the principal contributor (Fleck 1976). Calcium plays an important role in blood clotting, in muscles contraction and in certain enzymes in metabolic processes. Calcium tends to be a kind of co-ordinator among inorganic elements, if excessive amount of potassium, magnesium or sodium are present in the body, calcium is capable of assuming a corrective role (Fleck 1976). Although rickets in children is generally attributed to the lack of vitamin D, insufficient intakes of calcium and phosphorus, as well as an imbalance of these two minerals, may

Table 4
Mean ($\bar{x}$) standard deviation (sd) and coefficient of variation percent (CV%) for the various parameters determine din the sample

Sample	g/100g		mg/100g							Ratio		Mineral safety index					
	Moisture	Ash	Zn	Fe	Na	Mg	K	Ca	P	Na/K	Ca/P	Na	Zn	Ca	Mg	Fe	P
A_1-A_3;$\bar{X}$	6.7	27.0	43.5	13.6	71.6	55.4	119.9	59.2	171.5	0.8	1.8	0.7	95.7	0.5	2.1	6.1	1.4
SD	1.5	34.9	12.3	10.5	75.9	53.2	148.4	85.8	208.9	0.2	2.8	0.7	27.1	0.7	2.0	4.7	1.7
CV%	22.4	129.3	28.3	77.1	106.0	96.0	123.7	145.0	121.8	49.0	152.8	105.8	28.3	146.9	96.2	77.0	121.9
B_1-B_3;$\bar{X}$	6.7	21.3	54.6	17.9	48.3	30.5	68.9	50.2	128.7	0.8	1.9	0.5	120.0	0.4	1.1	8.0	1.0
SD	4.1	24.2	5.3	16.7	59.3	27.0	88.3	65.3	195.7	29.0	2.6	0.6	11.6	0.5	1.0	7.5	1.6
CV%	61.6	113.7	9.7	93.6	122.9	88.7	128.1	130.0	152.1	19.7	141.6	123.9	9.7	128.6	88.6	93.6	151.5
C_1-C_3;$\bar{X}$	5.7	32.6	32.8	7.5	26.0	30.5	37.5	13.4	10.8	0.7	1.5	0.2	72.2	0.2	1.1	3.4	0.3
SD	1.1	24.5	2.5	3.4	10.4	17.6	20.3	8.7	7.0	0.1	1.6	0.1	5.4	0.1	0.7	1.5	0.3
CV%	19.4	75.2	7.5	45.2	39.9	57.8	54.1	64.7	67.0	12.3	106.0	41.7	7.5	40.0	57.9	45.2	103.7
D_1-D_4;$\bar{X}$	7.3	26.4	26.9*	11.9*	276.2	290.9	346.8	204.7	477.5	0.9	1.7	2.7	59.2	1.7	10.9	5.3	3.8
SD	3.6	16.0	17.7*	9.5*	348.7	366.4	422.3	247.9	824.1	0.1	2.7	3.3	39.0	2.1	13.7	4.2	6.6
CV%	49.6	60.7	65.9*	79.7*	126.3	126.0	121.8	121.1	172.6	16.5	156.3	126.0	65.9	121.1	121.1	79.8	172.5
E_1-E_3;$\bar{X}$	18.8	32.9	35.6	7.6	50.5	50.9	60.4	46.7	50.2	0.9	1.8	0.5	78.0	0.4	1.9	3.4	0.4
SD	17.8	25.3	10.3	3.5	40.8	41.5	53.2	45.2	47.5	0.2	2.5	0.4	23.2	0.4	1.6	1.6	0.4
CV%	94.8	77.1	29.0	46.6	80.8	81.6	88.1	96.8	94.5	20.0	139.0	81.3	29.7	97.4	82.1	46.4	95.0
F_1-F_4;$\bar{X}$	3.7	25.7	47.8	13.5	175.5	72.3	199.6	471.0	195.3	0.9	22.0	1.7	105.2	3.9	2.7	6.0	1.6
SD	4.5	17.9	30.6	15.9	138.3	74.7	178.0	526.5	278.1	0.2	39.9	1.3	67.3	4.4	2.8	7.1	2.2
CV%	120.1	69.6	64.0	118.2	78.8	103.4	89.2	111.8	142.4	19.5	181.6	78.1	64.0	111.7	103.3	118.3	142.3
G_1-G_3;$\bar{X}$	4.6	36.2	28.8	8.5[a]	98.3	122.3	156.1	77.5	368.7	0.7	0.4	0.9	63.4	0.6	4.6	3.8	3.0
SD	4.4	23.3	8.9	1.2[a]	113.9	144.9	198.1	69.9	468.7	0.12	0.2	1.1	19.5	0.6	5.4	0.5	3.7
CV%	95.2	64.4	30.8	13.8[a]	115.9	118.4	126.9	90.2	127.1	16.9	59.5	116.0	30.8	90.6	118.6	13.9	126.8
H_1-H_3;$\bar{X}$	9.4	21.6	33.3	9.1	53.4	57.9	64.9	55.7	44.6	0.8	2.2	0.5	73.2	0.5	2.2	4.1	0.4
SD	3.0	19.8	11.3	1.7	35.5	45.9	44.5	40.1	44.1	0.03	2.0	0.3	24.9	0.3	1.7	0.8	0.3
CV%	32.2	91.3	34.0	18.6	66.4	79.3	58.5	72.0	98.7	3.6	87.1	66.7	34.0	71.7	79.3	18.7	97.1

[3]D_4 not used to calculate for X, SD, CV%; [a]G_2 not used to calculate for X, SD, CV%.

result in the disease. Osteomalacia, the adult rickets may also be due to this condition. Osteoporosis (bone thinning) is said to be more common among older people, females and whites, according to Moldswer *et al* (1965), than among younger people, males and non-whites. This shows that normal level of calcium in the diet should be maintained throughout life.

Low values of phosphorus were generally observed for the bones (A_2, B_2, C_2, D_2, and E_2) but very high (907.69mg/100g) in G_2. Other samples had good yield of phosphorus. Phosphorus is always found with Ca in the body, both contributing to the supportive structure of the body. It is present in cells and in the blood as soluble phosphate ion, as well as in lipids, proteins, carbohydrates and energy transfer enzymes (NAS 1974). Phosphorus is an essential component in nucleic acids and the nucleoproteins responsible for cell division, reproduction and the transmission of hereditary traits (Hegsted 1973). Our current report in phosphorus were generally lower than the values observed for various parts of male and female fresh water crab *(Sudananautes africanus africanus)* (Adeyeye 2002).

Table 3 depicts the Na/K and Ca/P ratios as well as the mineral safety index (MSI) for Na, Mg, P, Ca, Fe and Zn. 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 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 lost in the urine, which result to decrease the calcium level in 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. Such samples in our results included A_2, B_2, C_2, D_2, E_2, F_1, F_2, $H_1$and H_2. This may help to increase the calcium content of bones. Some researchers are advising that one should eat more foods that are high in calcium but low in phosphorus. Table 3 outlines the calcium to phosphorus ratio of the samples. Food is considered "good" if the ratio is above one and "poor" if the ratio is less than 0.50 (Nieman *et al* 1992). This meant 50.0% of our samples were poor in Ca/P ratio. A good consumption of vegetables will correct this anomally. This concern to the sodium and potassium ratio (Na/K). For prevention of high blood pressure, a Na/K ratio of 0.60 is recommended (Nieman *et al* 1992). The Na/K ratio of our samples were mostly above 0.60 with 96.15% samples greater than 0.60 while only 3.846% of the samples were slightly lower (0.55, sample A3). In other words, most of the samples would 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 can be consumed with the animal protein samples.

The standard mineral safety index (MSI) for the minerals are Na (4.8), Mg (15), P (10), Ca (10), Fe (6.7), and Zn (33). For Na, all MSI values were low except for D_4 (with a value of 7.53) with positive values for the difference between the standard value of MSI and the calculated value of MSI. This meant that the samples might not be overloading the body rich with sodium. For MSI of Mg only D_4 was above the USRDA by 15.81 times (Hathcock 1985). For P, Ca and Fe, the odd samples out respectively were D_4 (-3.69), F_1 (-0.23), A_3 (-4.77), B_3 (-9.86), D_2 (-3.44) and F_4 (-9.94). The implication of the above is that abnormally high levels of Na, Mg and P were present in D_4; Ca in F_1 and Fe in A_3, B_3, D_2 and F_4. Samples A_3, B_3, D_2 and F_4 could cause the reduction of zinc absorption in the small intestine (O'Dell 1984) and iron poisoning particularly in children (Herbert 1987). With the exception of F_1, all the Zn MSI values were greater than 33. This meant all the samples have Zinc values far above the recommended adult intake. The minimum toxic dose is 500mg, or 33 times the RDA (Hathcock 1985). High doses of zinc can be harmful. Zinc supplements can decrease the amount of high density lipoprotein circulating in the blood, increasing risk of heart disease (Anon 1986). Excess zinc interacts with other minerals, such as copper and iron, decreasing their absorption. In animals, zinc supplements decrease the absorption of iron so much that anaemia is produced (Greger 1987). When patients are given 150 mg of zinc per day, copper deficiency results. Intakes of zinc only 3.5mg/day above the RDA decrease copper absorption (Festa 1985). In animals, copper deficiency causes scarring of the heart muscle tissue and low levels of calcium in the bone (Anon 1986). Excess zinc also decreases the functioning of the immune system. From the foregoing, most of the samples would lead to excess zinc consumption with its deleterious effects.

The sources of the high levels of iron and zinc in the samples could have been due to either from the foods they consumed or from their environments or both. Zinc is of particular interest from automotive pollution consideration and is also greatly related to vehicular emission. Iron may have its origin in corrosion of iron materials, as most vehicles on roads are aged and disjointed parts are left on the road indiscriminately (Ogunsola 1994). The inwash of the corroded vehicles into the aquatic environment could lead to high biological accumulation of iron and zinc in the samples (Montaque and Montaque 1971) hence their high concentration in the samples.

The statistical results for all the samples are shown in Table 4. All the parameters analysed for or calculated were highly varied in the various samples. The high coefficients of variation percent in the majority of the samples attested to this. However, for all the samples the Na/K ratio CV% were generally low with values ranging between 3.61 - 28.95.

From the above, it is seen that the samples were good sources of the nutritionally valuable minerals. It is also seen that each part differently concentrated the minerals to different levels. While, some of the Ca/P ratios were good and the Na/K ratios would require nutritional correction in terms of consumption of low sodium and high potassium foods with them. Efforts should be made to reduce drastically the pollution of environment by iron and zinc which could accumulate to deleterious levels.

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