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Mineral and toxicant levels in yam *(Dioscorea rotundata)* diets

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ABSTRACT

This investigation studied the mineral and toxicant levels in different yam (Dioscorea rotundata) diets consumed by the Igboora people of Ibarapa Local Government Area of Oyo State, Nigeria. The yams were harvested and purchased from local farmers and transported to the University of Calabar. Five groups of diets were prepared vis-à-vis, boiled yam (BY), a mixture of pounded yam with soup and stew (PYSS), boiled yam with stew (BYS), fried yam with stew (FYS) and boiled yam with palm oil (BYPo). The raw yam was also analysed for its mineral and anti-nutrient composition and this served as control. The soup PYSS was prepared with the tender leaves of Okra (Abelmuschusesculentus) known locally as 'Ilasa'. The samples were homogenized, pelleted, dried in an air oven (Gallenburg, UK) at 55^0c for 24 hours, milled and analysed in triplicates using standard procedures. The mineral contents in (mg/100g)dw were Na(10.26 to 16.26), K(13.48 to 18.58), P(7.97 to 9.74)and Mg(28.21 to 28.90). The anti-nutrient concentration were (0.13 to 0.19), (1.91 to 4.37), (0.54 to 0.83) all in mg/100gdw for hydrocyanate, phytate and oxalate respectively. The results showed that the mineral concentration in all the diets were below therecommended daily allowances and the concentration of anti-nutrients in all the samples were below the toxic levels and so may not affect the bioavailability of the minerals.

Key words: Yam diets, *Dioscorea rotundata*, anti-nutrient, Abelmuschusesculentus, bioavailability

INTRODUCTION

Yam tubers constitute an important food crop in tropical countries including South America, the Caribbean, Asia and Africa. West Africa is the world's most prominent region for the production of yams, being only second to cereals in importance [1]. *Dioscorea* species constitute one of the staple carbohydrate foods for people in the tropics [2]. *Dioscorea rotundata* is the most popular variety of yams grown in Nigeria and over 600 species are cultivated all over the world [3]. It serves as a staple food thus forming a major source of energy to the diet. In Africa, the human diet has yam as a key component long before the western civilization and it is the same throughout the world today [4]. Yam also plays a major role in the socio-cultural life of a wide range of smallholder households especially in the dominant production zone of West Africa and it is also recognized as a prestige food crop in many African countries [5]. Mineral content of a food is probably more variable from species to species and can be affected by seasonal changes, cultural practice, climate and soil and other factors and to a lesser extent whether or not it is cooked or raw [6]. Phytate and oxalate are the major chelating agents in foods and their effects on the bioavailability of minerals have been well documented [7],[8],[9],[10].

The aim of the study therefore, is to prepare and analysethe mineral and anti-nutrient composition of the yam cultivated in Ibarapa local government area of Oyo State, Nigeria, into their various diets.

MATERIALS AND METHODS

Collection and transport of yam and vegetable samples

Freshly harvested tubers of *Dioscorea rotundata*/White Guinea yam were purchased from farmers in Igboora, Ibarapa Local Government Area of Oyo State, Nigeria. The yams were wrapped in dry greaseproof paper, packed into cartons and transported to Calabar by air. On arrival in Calabar, the yams were immediately taken to a laboratory where the research was conducted.

Similarly, fresh young leaves of okra plant *(Abelmuschusesculentus)*, commonly called "Ilasa" by the people of Ibarapa Local Government Area of Oyo State, Nigeria were purchased from the farmers and wrapped in dry greaseproof paper for transportation to Calabar. The leaves were stored in a refrigerator at 4^0C.

Preparation of "Ilasa" soup

The soup was prepared following the traditional method of the Ibarapa people of Oyo State. About 300g of the fresh vegetable was rinsed in clean tap water to remove sand and dust particles. It was then drained of excess water in a colander and chopped with a kitchen knife into fine pieces on a wooden chopping board. Meanwhile, one liter of clean tap water was put into an aluminiumpot and set on fire to boil. On boiling, the vegetable was added and allowed to boil for about 2 minutes before the melon, dawadawa (locust bean) and other ingredients were added. The pot was then left to boil for another 2 to 3 minutes with stirring occasionally before it was removed from the fire and allowed to cool. The recipe is as shown in table i.

Preparation of the stew. Recipe is showing in table ii.

The fresh tomatoes, onions and pepper were blended together and set aside. About 155g of red palm oil was placed in a stew pot and fried for about ten minutes, then the blended tomatoes, onions and pepper were added and allowed to boil for another 20 minutes. The meat and offals which were previously cleaned with tap water, salted and boiled until tender enough to homogenize were then added. The knorr cube and salt were added for seasoning and the pot was allowed to boil again for a further 10 minutes before setting it down.

Table i: Recipe for Ilasa soup

Ilasa leaves	-	300g (finely chopped)
Dawadawa	-	22g (ground)
Melon (Egusi)	-	83g (ground)
Potash (Kaun)	-	3g (crushed)
Salt	-	3g
Water	-	1L

1 cube of Knorr seasoning

Table ii: Recipe for stew

Cow leg	-	180g
Meat	-	380g
Tripe	-	125g
Spleen	-	62g
Intestine	-	83g
Tomatoes	-	160g
Pepper	-	21g
Onions	-	12g
Palm Oil	-	155g
Knorr cube	-	2cubes
Salt	-	7g

Treatment of yam samples for mineral and anti-nutrient analyses

The yams were divided into two main groups (the raw which served as control and the processed yam which was further sub-divided into treatment groups making a total of 6 groups). For the first group, two tubers of yams were washed in clean tap water to remove sand. They were peeled with a kitchen knife cut into thin slices and dried in an air ovenGallenburg UK, at 55^oC for 24 hours. The fresh dried yam samples (RY) were then homogenized into fine powder with mortar and pestle and stored in a clean, dried, sample bottles, from where samples were drawn for mineral and anti-nutrient composition analysis. For the processed yam diet group, the freshly harvested yam tubers were stored in a cool dry place until ready for use for the preparation of the various local yam diets that include boiled yam (BY), pounded yam with stew and soup (PYSS); fried yam and stew (FYS), boiled yam and stew (BYS); boiled yam and palm oil (BYPo).

Pounded yam with soup and stew:A10kg weight fresh yam tuber was washed in clean tap water to remove sand, peeled with a kitchen knife and cut into chunks. This was placed in an aluminium pot and boiled with tap water without salting until it was soft enough to pound. It was then pounded with a local mortar and pestle before the soup "*Ilasa*" and stew were added and then homogenized, dried in Gallenburg oven at 55^0C for 24 hours, cooled and stored for the analysis.

Boiled yam and stew: 10kg of yams tubers were washed in clean tap water to remove sand, peeled with kitchen knife, cut into slices and boiled in salted water until soft enough to eat. The yam was then homogenized with another pot of prepared stew, dried in the same oven at 55^oC for 24 hours, cooled and used for the analysis.

Fried yam and stew: A10kg weight of yams were washed to remove sand, peeled with kitchen knife and cut into medium slices for quick frying. A 300g of palm oil was allowed to fry in a deep frying pan and the yam slices were added in small quantity at a time. Two hundred milliliter of water was added to the frying oil and yam at interval to soften the yam and fried until golden brown. The fried yam was then homogenized with the already prepared stew and the homogenate dried in the same oven at 55^oC for about 24 hours, cooled and used for the analysis.

Boiled yam with palm oil: The same quantities of yams were washed in clean tap water to remove sand. The yams were then peeled with kitchen knife, washed again before cutting into slices. It was then put in an aluminium pot, salted and boiled until soft enough to eat after which it was homogenized with 126g of palm oil. This was dried in the oven at 55^0C for 24 hours, cooled and used for the analysis.

Boiled yam: A 10kg weight of yams were washed, peeled and cut into slices. It was then put in an aluminium pot; water added and boiled until soft enough to eat. The yam was further cut into small pieces, dried in the same oven at 55^0C for 24 hours, cooled and used for analysis.

Group 1: RY(raw yam which served as control
Group 2: BY (boiled yam)
Group 3: PYSSpounded yam, soup and stew
Group 4: BYSboiled yam with stew
Group 5: FYSfried yam with stew
Group 6: BYPOboiled yam with palm oil

Preparation of samples for mineral analysis
One gram (1g) of the ground samples were accurately weighed into conical flasks. Twenty-five milliliters of concentrated nitric acid was added to each sample. This wasfollowed by five milligrams of perchloric acid. The conical flasks with the contents were gently heated (50 – 70^0C) on a Stuart hot plate until there was a color change from brown to colorless. The digests were made up to 100ml with deionized distilled water. Appropriate dilutions were made for each element and triplicate determinations were also carried out. Calcium was determined by The Randox colorimetric method (Randox Laboratories Ltd, Crumlin, Co Antrim, UK). Sodium, Potassium, Phosphorus, Iron and Magnesium were determined by The TECO diagnostic colorimetric method (Anaheim California, U.S.A) Oxalate was estimated by the [11] method, while the alkaline titration method of [12] was used for hydrocyanate determination. The method of [13] was used in the determination of phytate. The method of[14] was used to determine saponin and tannin. Alkaloids were determined by the method of [15].

Statistical analysis
The experimental data were analyzed for statistical significance by one-way analysis of variance (ANOVA) using the SPSS computer-based program. All data were expressed as mean ± SEM and the probability tested at 95% level of significance ($P<0.05$) establish.

RESULTS AND DISCUSSION

The results of the mineral element composition of yam *(Dioscorea rotundata)* diets are as presented in table iii. The data showed that boiled yam (BY) had the highest calcium content 7.70mg/100gdw with boiled yam with palm oil (BYPo) recording the lowest at4.65mg/100gdw. Iron content was low in all the diets ranging from 1.27 to 2.36mg/100gdw. Pounded yam with soup and stew (PYSS) had the highest level of magnesium at 28.66mg/100gdw while BY had the lowest level at 28.21mg/100gdw. There were no significant ($P<0.05$) differences in the potassium levels between the raw and boiled yam. The level of potassium in the diets ranged from 13.48mg/100gdw to 18.58mg/100gdw. The concentration mg/100g dried weight of sodium in boiled yam was highest at 16.26mg/100gdw while fried yam with stew (FYS)had the lowest sodium level at 10.25mg/100gdw. Phosphorus concentration ranged from 8.32mg/100gdw to 9.74mg/100gdw. The anti-nutrient composition (mg/100g)dry weight in the diets are as shown in table iv. Phytate levels were RY(7.85), BY(4.32), PYSS(1.91), BYS(2.25), FYS(2.37) and BYPo(2.17). Hydrocyanic acid levels ranged from 0.13 to 0.19 with BYPo having the lowest value while BY and FYS had the highest values. Total oxalate contents ranged from 0.54 to 0.83mg/100gdw. Saponin levels ranged from 5.41% to 12.71%. Tannin concentration was highest in the boiled yam but reduced in the other diets. Alkaloid was lowest in BYPo at 1.60%. Anti-nutrient levels in most of the diets were considerably reduced when compared to the raw yam.

Tableiii **Mineral element contents of the raw, boiled yam and various yam diets (mg/100g) Samples**

	RY	BY	PYSS	BYS	FYS	BYPo
Calcium	8.13 ±0.04	7.70 ±0.10*	5.76 ±0.01*	5.53 ±0.03*	6.54 ±0.07	4.65 ±0.05*
Sodium	15.82 ±0.36	16.26 ±0.05*	13.61 ±0.02	11.75 ±0.03*	10.26 ±0.28*	10.64 ±0.31*
Potassium	19.85 ±0.07	18.58 ±0.29*	13.48 ±0.02*	16.53 ±0.02*	17.70 ±0.01*	17.24 ±0.02*
Phosphorus	11.72 ±0.01	9.74 ±0.01*	8.42 ±0.00*	8.65 ±0.31*	8.32 ±0.01*	8.47 ±0.00*
Iron	1.72 ±0.0	1.27 ±0.01*	2.36 ±0.00*	2.22 ±0.03*	2.24 ±0.01*	2.35 ±0.01*
Magnesium	28.19 ±0.02	28.21 ±0.04*	28.66 ±0.01	28.62 ±0.01*	28.22 ±0.01*	28.54 ±0.02*

*Values are expressed as mean ± SEM; *P<0.05 vs RY*

Table iv Anti-nutrient contents of raw, boiled yam and various yam diets

(mg/100g)				**%**		
Samples	**Hydrocyanic acid**	**Phytate**	**Oxalate**	**Tannin**	**Saponin**	**Alkaloids**
RY	0.23 ±0.01	7.85 ± 0.03	1.07 ±0.01	0.41 ±0.00	12.76 ±2.36	2.61 ±0.72*
BY	0.19 ±0.02*	4.37 ± 0.10*	0.54 ±0.01*	0.38 ±0.01	12.71 ±2.34	2.02 ±0.01*
PYSS	0.17 ±0.01*	1.91 ± 0.03*	0.74 ±0.03*	0.12 ±0.02	5.41 ±0.02*	0.63 ±0.03*
BYS	0.17 ±0.02*	2.25 ± 0.03*	0.83 ±0.02*	0.14 ±0.02	8.22 ±0.01*	0.80 ±0.01*
FYS	0.19 ±0.01*	2.37 ± 0.01*	0.77 ±0.04*	0.12 ±0.02	9.03 ±0.03*	2.81 ±0.01*
BYPo	0.13 ±0.00*	2.17 ± 0.01*	0.83 ±0.01*	0.17 ±0.01	7.40 ±0.00*	1.60 ±0.01*

*Values are expressed as mean ± SEM; *P<0.05 vs RY*

Minerals are important components of diets because of the physiological and metabolic roles they play in normal body functions. Though minerals are not lost due to heat, they are usually leached if cooked in boiling water, [6]. The level of calcium in boiled yam (BY) was significantly (P<0.05) higher than in the other diets. [16]reported 9.60g/kgDM and 9.51g/kgDM for raw and boiled*D.rotundata* respectively. Calcium functions as a component of skeleton and teeth where it occurs as a salt with phosphate. Calcium is also used in the activation of a number of hydrolytic enzymes [17]. The values of calcium concentration obtained in this study are far below the recommended daily allowance of 500 – 800mg/day for children and 1000mg for adult. The sodium levels in the diets except PYSS are higher than the WHO recommended daily allowance of 10mg/day for adult male and below the 15mg/day for female. Sodium is used to maintain blood pressure and chronic changes in salt nutrition can change blood pressure and influence the course of cardiovascular disease [18]. Potassium is important in the regulation of heart beat, neurotransmission and water balance in the body [19]. The potassium levels in all the diets are low and cannot meet the WHO recommended daily allowance of 2000mg/day for adult and 1000mg/day for children. Phosphorus levels in all the diets were higher than reported by[16]in boiled yam. Dietary phosphate deficiency is reported to be rare because phosphate concentration in plant and animal foods is well above requirement and because of the efficient absorption of phosphate 50 to 90% [17]. Iron concentration in the yam diets ranged from 1.27mg/100 to 2.36mg/100g and 1.72mg/100g in the raw yam which is lower than reported by[20] for raw D.dumetorum. Iron is needed for the formation of haemoglobin which carries oxygen from the lungs to the body cells. Magnesium levels in the yam diets were comparable to the level in the raw yam. Most enzymes that utilize adenosine triphosphate (ATP) require magnesium and one of the enzymes using magnesium pumps sodium out of cells and potassium into cells [21]. Magnesium also contributes to DNA and RNA synthesis during cell proliferation. The recommended daily allowance for magnesium is between 80 – 320mg/day for female. The levels of anti-nutrients in foods may affect their nutritive values. Oxalate form complexes with calcium, potassium, Iron thus reducing their absorption [22]. Oxalate levels in the yam diets ranged from 0.54 to 0.83mg/100g and 1.07mg/100g in the raw yam. Cooking showed considerable reduction in oxalate but in only fairly affected [23]. This may explain the appreciable reduction in the oxalate levels of the yam diets compared to the raw yam. High oxalate diet increases the risk of renal calcium oxalate formation and may affect calcium absorption [18]. Phosphorus in phytic acid (Inositol hexaphosphate) is not usually available to man except through the activity of phytate, an enzyme which hydrolysis phytic acid into phosphoric acid and Inositol [24].The mineral content of plants generally depends on the soil composition in which they are cultivated.Phytate levels in this study ranged from 2.17mg/100g to 4.37mg/100g. The phytate level in the raw yam was considerably high at 7.85mg/100g compared to the diets which suggested that cooking reduced the level of phytate in the diets. Hydrocyanate levels in the study are very low when compared to the lethal dose of 50 to 60mg reported for an adult human. Hydrocyanate was lowest in BYPo. Palm oil is usually added to grated cassava in the production of 'gari'. This is believed to reduce the hydrocyanate content of raw cassava. Some types of saponin are health friendly.They serve as natural antibiotics which help the body to fight infection and microbial invasion [25]. Saponin also inhibit the growth of cancer cells and help lower blood cholesterol hence are useful in the treatment of cardio vascular diseases and other health problems [26]. Tannin levels in the raw and boiled yam were 0.41% and 0.38% respectively. The levels in the other diets were significantly ($P<0.05$) reduced ranging from 0.12% to 0.17%. Raw yam had the highest level of tannin. Tannins are water soluble compounds and can therefore be eliminated by cooking [27]. Simple processing such as boiling removes the alkaloids present in most cultivated species of yams [28]. The results of the alkaloid levels in raw and boiled yam were lower than the levels reported for five hybrids of D.alata by [29]. Most alkaloids according to[30] and [9] are toxic to animals and inspite of their medicinal uses can cause gastrointestinal upsets and neurological disorders.

CONCLUSION

The mineral contents of the yam *(Dioscorea rotundata)* diets consumed by the people of Igboora were very low and cannot meet the WHO recommended daily allowances. Fruits and vegetables contain high levels of minerals particularly potassium and consumption of these foods can supplement the deficiencies of minerals in the diets. The anti-nutrient levels in all the diets were considerably reduced on processing. The low levels of anti-nutrients in these diets suggest that the yam diets may not have adverse effects on absorption and bioavailability of certain minerals.

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