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Research Article

Dietary Sufficiency in Mineral Contribution from African Yam Beans (*Sphenostylis stenocarpa*) and Soya Beans (*Glycine* sp) Consumed in Southern Nigeria

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Abstract

Some of our ancestors' foods are noticeably lacking in modern diets and the human biology has not evolved significantly differently [1]. Speculation is that, plethora of diet related disorders and/or non- communicable diseases could be linked to human gastrointestinal track evolutionary factors. Despite efficacy of supplements in treating degenerative diseases, minerals are often absorbed more efficiently by the body if supplied in foods rather than as supplements [2]. Consequently, data driven promotion of minerals intake from diets rich in legumes is targeted, using African Yam Beans (AYB). It is an indigenous crop that was in our ancestor's food, threaten with extinction [3,4] that can foster nutrition security. The specific challenge is to generate data on African yam beans mineral contribution in the dietary vis-a-vis the nutritionally dense soya beans.

About 3g of each sample were oven dried at 110°C and then reduced to < 2µm diameter by crushing. Further pulverised because of inhomogeneity of samples, was transferred to the sample compartment of an X-Ray Fluorescence (XRF) Spectro Xepos model 03STD Gas serial Spectro-11001700, mixer mill MM400. They were then screened for their elemental composition. Results were calculated automatically as the necessary sample details were computed in the software. Fifty-one (51) elements were quantified in each sample. Twenty-five (25) in their free- state and twenty-six (26) existed as oxides. These oxides, 16 were minerals and those in their free state, 7 were minerals. Therefore 23 minerals were obtained from AYB. Soya beans had same complement of predominant elements (≥ 100ppm) and both contained all known essential minerals. Elements in trace amount (≤ 20ppm) for soya beans were at micro-levels (≤100ppm) in AYB, except for silicon, which was significantly high in AYB to about (189.4ppm). Corollary, the naturally highly reactive chlorine and barium, were detected in their free states. Sodium was not detected. X-Ray Fluorescence Spectrometry analytical method apart from giving a total profiling of all elements present in these samples, raised question on the existence of some mineral elements in their free states in food items. Thus, further research on their bioavailability. Result on total mineral composition of African yam beans as a legumes indicated this food can indeed be resource-efficient in mineral contribution to the diet and highly economical food sources of minerals.

Keywords: Legumes; Minerals Profiling; X-Ray Fluorescence (XRF) Spectrometry

Introduction

Modern diet is a far cry from the hunter- gatherer diet as it is in modern diets and the human biology has not evolved significantly different [1]. One of the constituent elements of food systems is consumer behaviour which is a factor that defines dietary patterns and dietary changes. In Nigeria, current changes in food consumption trends and dietary patterns involving preference for exotic (borrowed) diets, cuts across urban- rural settings as well as low- middle- high income socio-economic strata. This changing diet has been implicated as driver of multiple burden of malnutrition e.g. under nutrition, overweight, obesity and non- communicable diseases. Under nutrition presenting as micro nutrient deficiencies are prevalent across the globe [5]. Consequently, the speculation is that the plethora of diet related disorders and / or non- communicable diseases could be linked to human gastro-intestinal track evolutionary factors. Of all the components of food, micronutrients are major victims of modern food supply chain. Inorganic substances required by the body for human nutrition and referred to as minerals and/or micronutrients if compromised in a food environment have grave consequences for diet, nutrition and health. These are usually needed either in macro- amounts or micro quantities.

However, minerals are often absorbed more efficiently by the body if supplied in foods rather than as supplements [2]. A diet that is short in one mineral may well be low in others, therefore, it is important to consider the "Internet of Things" concept for a data driven choices in promoting minerals contribution from legumes in the diet within the context of a total mineral profiling of legumes using African Yam Beans (AYB) and soya beans as case studies. More so as AYB is among indigenous crops that were in traditional food systems and in our ancestor's food, threaten with extinction [3,4]. The specific challenge is to generate data on African yam beans minerals contribution in the dietary vis-a-vis the much acclaimed highly nutritious soya beans. For according to Sanusi et al. [6]" data on many foods are still incomplete and may be inadequate for representativeness of foods eaten in Nigeria". The purpose and scope of this study is to compare the total mineral composition of African yam beans with that of soya beans in order to rationalise that AYB legume can indeed be resource-efficient in mineral contribution to the diet. In addition, possibly promote it as a profitable industrial crop for restoring the ecosystem of marginal lands in Southern Nigeria, where it used to be prominent in traditional farming systems.

Minerals are essential in the diet as they cannot be produced by the human body. Today farming practices that have depleted the soil of necessary minerals and water supplies that have been polluted and poisoned, populations have become mineral malnourished. Accordingly, one can have all the air, water, protein, carbohydrates, fats, and vitamins but won't be fully functioning organism without a complete balance of minerals [7]. Thus, the increase dependence on mineral supplements in the management of plethora of health problems both chronic and acute have been associated with lack of certain minerals in our diets. As early as the beginning of this century, it had been asserted that knowledge of the chemical composition of foods is the first essential in the dietary treatment of disease or in any quantitative study of human nutrition [8]. This underscores the importance of food composition data which has wide application including compilation of food composition databases [9]. Variability in composition of foods between countries, owing to a number of factors some of which are soil, cultivar, vegetation etc. make it imperative to build food data composition of indigenous crops. Another purpose for this study was to complete missing values in already existing literature on mineral composition of soya beans and African yam beans, as total X-ray mineral profiling was conducted.

Materials and Methods

Minerals content of the beans samples were determined using X-Ray Fluorescence Spectrometer (XRF) Spectro Xepos model 03STD Gas, Serial Number Spectro-11001700, in accordance with ISO 18227. About 3g of each sample were oven dried at 110˚C, unwanted material removed and samples reduced to < 2μm diameter by crushing. Crushed samples were further pulverised for thorough homogeneity of samples using a mixer miller MM400. It was then processed into pressed pellets, transferred to clean prolene foil 4μ roll and then into a sample vial, labelled, arranged in the sample tray and finally transferred to the sample compartment of the X-ray fluorescence equipment for screening of elemental content. The concentrations of elements were obtained via a previously stored calibration with certified reference materials. Result was calculated automatically as the necessary sample details were computed in the software.

Results

Fifty-one (51) elements were quantified in each sample. Twenty-five (25) in their free-state and twenty-six (26) existed as oxides. Of these oxides, 16 were minerals and those in their free states, 7 were minerals. Therefore 23 minerals were obtained from AYB. Soya beans had same complement of predominant elements (≥ 100ppm) except for silicon, which was significantly high in AYB to about (189.4ppm). Significantly both contained all known essential minerals. Elements in trace amount (≤ 20ppm) for soya beans were at micro-levels (≤100ppm) in AYB. Corollary, the naturally highly reactive chlorine and barium, were detected in their free states and sodium was not detected.

Discussion

That legumes are rich in mineral composition can be rationalised as fifty-one (51) elements each were profiled in soya beans and African yam beans. The Nigerian Food Composition Table has information on calcium, iron, phosphorus, sodium, zinc for African yam beans and for soya beans; calcium, iron, magnesium, phosphorus, potassium, sodium, zinc, copper and manganese. In this analysis twenty-six (26) elements existed as compounds and 25 as free elements (Tables 1, 2). In all 23 minerals were obtained from AYB. Elements found at micro- levels (<100ppm) in AYB were in trace amounts (≤ 20ppm) in soya beans (Tables 3, 4). In considering predominant elements (Table 5) and those present in micro levels (Table 4), AYB was a superior contributor of minerals to the diet when compared to soya beans. On the basis of total mineral composition, chlorine and bromine were the most abundant in both samples. While chlorine was the overwhelmingly predominant element in AYB (Figure 1), bromine was most abundant in soya beans (Figure 2). Chlorine is known to have high electron affinity and high electronegativity, thus making it a strong oxidizing agent. It is important to consider the implication of its release and presence in the gastrointestinal tract during digestion and subsequent assimilation of a meal containing AYB.

S/No	Compounds	Concentration (% Elemental content)		Minerals
		African Yam Beans	Soya Beans	
1	Magnesium oxide MgO	0.215	0.254	·
2	Aluminium oxide Al_2O_3	< 0.0038	< 0.0038	·
3	Silicon oxide SiO_2	0.04051	< 0.0011	·
4	Phosphorus oxide P_2O_5	0.575	0.7823	·
5	Sulphur oxide SO_3	0.9584	1.162	·
6	Potassium oxide K_2O	0.5441	1.244	·
7	Calcium oxide CaO	0.1563	0.5982	·
8	Titanium oxide TiO_2	0.00067	0.00078	
9	Vanadium oxide V_2O_5	< 0.00018	0.0038	·
10	Chromium oxide Cr_2O_3	< 0.00015	< .00015	·
11	Manganese oxide MnO	0.01467	O.01862	·
12	Iron oxide Fe_2O_3	0.6337	0.6449	·
13	Cobalt oxide CoO	< 0.00039	<0.00039	·
14	Nickel oxide NiO	0.0038	0.00619	·
15	Copper oxide CuO	0.00368	0.00361	·
16	Zinc oxide ZnO	0.01278	0.0158	·
17	Arsenic oxide As_2O_3	< 0.0.00007	<0.00007	·
18	Rubidium oxide Rb_2O	0.04124	0.1228	
19	Strontium oxide SrO	< 0.00006	< .00006	
20	Zirconium oxide ZrO_2	0.00026	< .00014	
21	Niobium oxide Nb_2O_5	0.00036	0.0003	
22	Tin oxide SnO_2	0.0032	0.00318	·
23	Antimony oxide Sb_2O_5	0.0124	0.0115	
24	Tantalum oxide Ta_2O_5	0.00869	0.00903	
25	Tungsten WO_3	< 0.00013	< .00013	
26	Lead oxide PbO	0.00024	< .00011	

Table 1: Inorganic compounds profile for African Yam beans and Soya beans.

S/No	Elements	Concentration ppm		Miner-als
		African Yam Beans	Soya Beans	
1	Chlorine	6339	402	·
2	Gallium	1.8	<0.5	
3	Germanium	<0.5	<0.5	
4	Selenium	<0.5	<0.5	·
5	Bromine	7.2	40.8	·
6	Yttrium	42	<0.5	
7	Molybdenum	8.5	7.9	·
8	Silver	30.4	30.6	
9	Cadmium	<2.0	<2.0	·
10	Tellurium	33.7	32	
11	Iodine	28.5	26.6	·
12	Cesium	<4.0	<4.0	
13	Barium	121.1	105.3	
14	Lanthanum	<2.0	<2.0	
15	Cerium	<2.0	<2.0	
16	Praseodymium	3.3	<2.0	·
17	Neodymium	3.6	2.6	·
18	Erbium	<5.1	<5.1	
19	Ytterbium	4.2	3.3	
20	Hafnium	3.2	2	
21	Mercury	<1.0	<1.0	
22	Thallium	<1.0	<1.0	
23	Bismuth	<1.0	<1.0	
24	Thorium	11.2	12.9	
25	Uranium	15.2	17.7	

Table 2: Elemental composition and concentration (ppm) in African Yam Beans and Soya Beans.

Elements	African Yam Beans	Soya Beans
Titanium	4	4.6
Nickel	29.9	48.6
Copper	29.4	28.8
Gallium	1.8	
Bromine	7.2	40.8
Yttrium	42	
Zirconium	1.9	
Niobium	2.5	2.1
Molybdenum	8.5	7.9
Silver	30.4	30.6
Tin	25.2	25.1
Antimony	93.3	86.5
Tellurium	33.7	32
Iodine	28.5	26.6
Praseodymium	3.3	
Neodymium	3.6	2.6
Ytterbium	4.2	3.3
Hafnium	3.2	2
Tantalum	71.2	73.9
Lead	2.2	
Thorium	11.2	12.9
Uranium	15.2	17.7
Vanadium		21

Table 3: Elements concentration at micro-levels (<100 ppm).

Elements	African Yam Beans	Soya Beans
Aluminium	< 20	< 20
Silicon		< 5.1
Chromium	< 1.0	< 1.0
Cobalt	< 3.0	< 3.0
Gallium		< 0.5
Germanium	< 0.5	< 0.5
Arsenic	< 0.5	< 0.5
Selenium	< 0.5	< 0.5
Strontium	< 0.5	< 0.5
Yttrium		< 0.5
Zirconium		< 0.1
Cadmium	< 2.0	< 2.0
Caesium	< 4.0	< 4.0
Lanthanum	< 2.0	< 2.0
Cerium	< 2.0	< 2.0
Praseodymium		< 2.0
Erbium	< 5.1	< 5.1
Tungsten	< 1.0	< 1.0
Mercury	< 1.0	< 1.0
Thallium	< 1.0	< 1.0
Lead		< 1.0
Bismuth	< 1.0	< 1.0
Vanadium	< 1.0	

Table 4: Elements in trace amounts and their abundance (< 20ppm) .

Elements	African Yam Beans (ppm)	Soya Beans (ppm)
Magnesium	1300	1530
Silicon	189.4	
Phosphorus	2509	3414
Sulphur	3838	4654
Chlorine	633.9	402
Potassium	4516	10330
Calcium	1117	4275
Manganese	113.6	144.2
Iron	4432	4511
Zinc	102.7	126.9
Rubidium	377.1	1123
Barium	121.1	105.3

Table 5: Predominant elements and their concentration (≥ 100ppm).

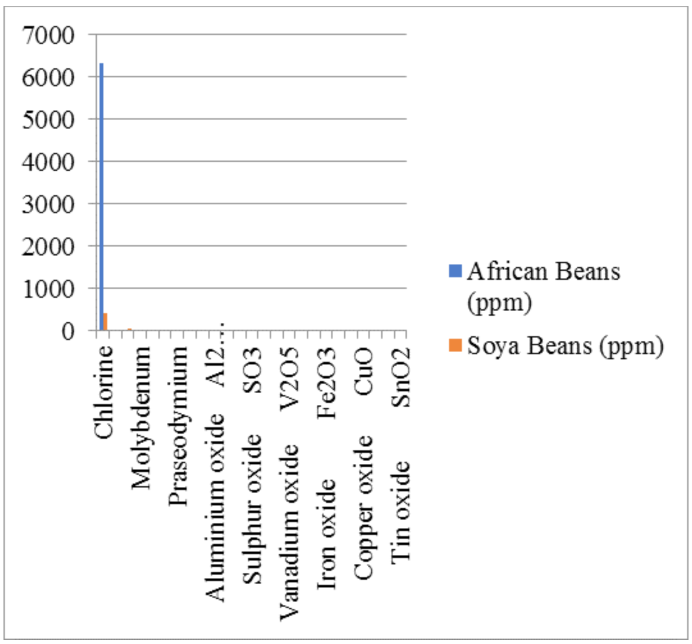

Figure 1: Comparative analysis of concentrations of all minerals found in African yam beans and soya beans.

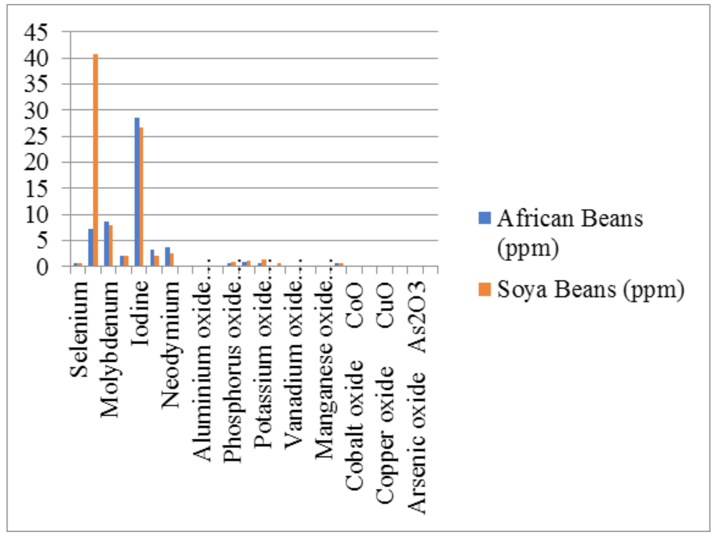

Figure 2: Comparative analysis of concentrations of minerals in African yam beans and soya beans excluding chlorine.

It has been postulated that the free chlorine in the GIT during digestion can enter the ligand- gated ion channels for chloride, one of which is anoctamin (AN01) channels. AN01 is highly expressed in human gastrointestinal interstitial cells and of cajals, which are proteins that serve as intestinal pacemakers for peristalsis [10]. These proteins may also have roles as tumour suppressors e.g. the calcium- activated chloride channel [11,12]. This highlights the nutritional significance of AYB in the diet as a good source of dietary chlorine. On the other hand, iodine level in both legumes was of nutritional significance, but being more abundant in soya beans. With an optimal dietary iodine intake for healthy adults of 150-250µg/day and an estimated 2 billion individuals having insufficient iodine intake in developing countries, soya beans and AYB portends a major source of dietary iodine in these populations. Importance of dietary iodine is in the health implication of iodine deficiency which among others include impairment of growth and neurodevelopment during pregnancy and infancy, reduction of somatic growth, cognitive and motor functions during childhood. Released free iodine can be absorbed in the stomach and duodenum through the Sodium/Iodine Symporter (NIS) which mediates active iodine absorption [13].

Another difference between these legumes was the quantity of silicon found in AYB and soya beans. While silicon was among the predominant element for AYB, in soya beans it was in trace amounts (Tables 4, 5). Nutritionally, silicon has been named an ultra-trace element [14]. Also, five of the six known ultra-trace elements were all found in AYB: silicon, vanadium, nickel, selenium and arsenic [15]. Four of the five ultra-trace elements in these food items existed as oxides (Table 1) while selenium existed as a free element (Table 2). That AYB, apart from containing all the essential minerals, was also a good source of ultra-trace elements is worthy of note. The health benefits of silicon are numerous, some of which include but not limited to: maintenance of natural glow of skin, reduces signs and symptoms of aluminium toxicity, help strengthen bones, reduces risk of alopecia, aids in healing bone dislocation and fractures etc., [16].

It has been reported that the predominant form of selenium found in plants is selenomethionine, curiously, selenium in this samples was in the free state and not as selenate (SeO_4^{2-}) or selenite (SeO_3^{2-}) forms in which inorganic selenium is taken up by plants [17] Popular selenium intake in humans has been from animal sources and since food processing method may cause its loss through volatilities, its existence in free state in AYB and soya beans requires appropriate processing methods that would minimise loss of selenium. Selenium (one of the trace elements) and zinc (one of the predominant minerals) are commonly referred to as antioxidant nutrients, but these elements have no antioxidant action themselves and are instead required for the activity of some antioxidant enzymes. Therefore, regular consumption of AYB is a guaranty for healthy living. Among the predominant elements, chlorine (633.9ppm) and barium (121.1ppm) existed in their free states in AYB contrary to literature which states that these two elements do not exist free except in combine states. Even though there is no nutritional information on barium, it is not carcinogenic and does not bio-accumulate [18,19].

Considering the array of minerals in AYB, consuming population can possibly be protected from osteoporosis and fracture risk. Therefore, implication for increasing intake of legumes like AYB may have been contributing to high Bone Mineral Density (BMD) for consumers in ancient days. This then calls for interventions to arrest its extinction. This dietary sufficiency in minerals contribution from legumes (AYB and soya beans) has public heath significance within the context of consumer behaviour towards healthy diets. Promoting these foods' nutritional value through pairing nutrition education and dissemination project on their mineral contents can be an entry point for intervention pathway meant to increase consumption of AYB as a nutritious food's [20]. Furthermore, the natural levels of heavy metals like mercury, lead and cadmium in AYB and soya beans were low. Soya beans had been reported as containing 0.09ppm cadmium [21]. AYB cadmium concentration is put at < 2.00ppm, lead 0.00024ppm and mercury <1.0ppm. In this study soya beans' concentration for cadmium, Lead and mercury were < 2.00ppm <0.00011ppm, <1.0ppm respectively. Therefore, their dietary component does not present health hazard.

Conclusion

In conclusion, whatever mineral element not detected or quantified by this analytical method is presumed not found in these two legumes. Analytical method used in this study gave values that were very revealing. Values for mineral composition for AYB using other methods have been reported [22,23] and major disparity was the detection of sodium in AYB which was conspicuously not found in this research work. Apart from the analytical method employed, geography of crop cultivation could affect results obtained. The nutritive value of AYB is considered to be appropriate [24,25] and since solid foods are a major source of silicon [26], adequate inclusion of AYB in the dietary of growing children as per its use in formulating weaning diets is highly recommended. The dietary implication for African yam beans as a component of a diet is that it is indeed rich in mineral contribution to the consumer.

Reference

1. Leigh BC (1994) Silicon's Elemental Benefit in Victory Nutrition.
2. British Nutrition Foundation (2015) science/nutrients/minerals-and-trace- element.
3. Porter D (1992) Economic botany of *Sphenostylis* (Leguminosae). Economic Botany 46: 262-275.
4. Amoatey HM, Klu GYP, Bansa D, Kumanga FK, Aboagye LM, et al. (2000) The African Yam Beans (*Sphenostylis stenocarpa*): A neglected crop in Ghana West African. Journal of Applied Ecology 1: 53-60.
5. Black RE, Victora CG, Walker SP, Bhutta ZA, Christsian P, et al. (2013) Maternal and Child Nutrition Study Group.2013. Maternal and Child under-nutrition and overweight in Low-income and middle-income countries. Lancet 382: 427-451.
6. Sanusi RA, Akinyele IO, Ene-Obong HN, Enujiugha V (2017) Nigerian Food Composition Table.
7. Mineral Role Fundamentals (2016) Eidon Ionic Minerals.
8. MacCance RA, Widdowson EM (1940) The Chemical Composition of Foods. Medical Research Council Special Report Series No. 235. His Majesty's Stationary Office. London.
9. Church SM (2009) Euro FIR Synthesis Report No.7: Food composition explained. Nutrition Bulletin 34: 250-272.
10. Sanders KM, Zhu MH, Britton F, Koh SD, Ward SM (2012) Anoctamins and gastrointestinal smooth muscle excitability. Experimental Physiology 97: 200-206.
11. Hartzell C, Putzier L, Arreola J (2005) Calcium-activated chloride channels. Annual Review of Physiology 76: 719-758.
12. Evans SR, Thoreson WB, Beck CL (2004) Molecular and functional analyses of two new calcium-activated chloride channel family mem-

bers from mouse eye and intestine. Journal of Biological Chemistry 279: 41792-41800.

13. Zimmermann MB (2012) Iodine and Iodine Deficiency Disorders. In: Edward J, et al. Present Knowledge in Nutrition. Pg No: 554-565. International Life Science Institute: John Wiley and Sons, Inc.

14. Nielsen FH (1991) Nutritional requirements for boron, silicon, vanadium, nickel and arsenic: Current knowledge and speculation. FASEB Journal 5: 2661-2667.

15. Nielsen FH 1(993) Ultra-trace elements of possible importance for human health: An Update. Prog Clin Biol Res 380: 355-76.

16. Carlisle EM (1986) Silicon as an essential trace element in animal nutrition. In: O'Connor ED. Silicon biochemistry. Pg No: 123-39. Chichester United Kingdom. John Wiley and Sons Ltd.

17. Terry E, Diamond A (2012) Selenium. In: Present Knowledge in Nutrition, Zimmermann MB (2012) Iodine and Iodine Deficiency Disorders. In: Edward J, et al. Present Knowledge in Nutrition. Pg No: 568 - 579. International Life Science Institute: John Wiley and Sons, Inc.

18. Barium (2016) ESPI Metals.

19. US EPA (2016) Toxicity Profiles, Ecological Risk Assessment.

20. HLPE (2017) Nutrition and food systems. A report by the High Level Panel of Experts on food security and nutrition of the committee on world food security, Rome.

21. Shibamoto T, Leonard F (1993) Food contaminations from Industrial waste. In: Introduction to food toxicology (1st Edition). Pg No: 126-139.

22. Ameh GI (2007) Proximate and mineral composition of seed and tuber of African Yam Beans *Sphenostylis stenocarpa* (Hoechst. Ex. A. Rich.) Harms. ASSET Series B: 1-10.

23. Ndidi US, Ndidi CU, Olagunju A, Muhammad A, Billy FG, Okpe O (2014) Proximate, Antinutrients and mineral composition of raw and processed (boiled and Roasted) *Sphenostylis stenocarpa* seeds from Southern Kaduna, Northwest Nigeria. International Scholarly Research Notices Nutrition 2014: 280837.

24. Obizoba IC, Souzey J (1998) The Nutritive value of African Yam Beans (*Sphenostylis stenocarpa*): Nitrogen and mineral utilization. Ecology of Food and Nutrition 22: 297-305.

25. Nwokolo E (1987) A Nutritional Assessment of African Yam Beans *Sphenostylis stenocarpa (*Hochstex A. Rich) Harms, and Bambara Groundnut *Voandzele subterranean* L. Journal of the Science of Food and Agriculture 41: 123-129.

26. Jugdaohsingh R, Simon HC, Anderson KL, Tucker HED, Kiel P, et al. (2002) Dietary silicon intake and absorption. Am J Clin Nutrvol 75: 887-893.