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Trace Elements Profile Of Some Legumes Consumed In Plateau State, Nigeria

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Abstract

Trace elements are essential to both plants and animals for the maintenance of life and for healthy living. Deficiency of any of the elements, especially the 5 well-characterized elements: Fe, Zn, Cu, Se and I, will results in symptoms associated with that particular element. Leguminous food crops constitute a large portion of staple foodstuffs of Nigerians, especially in Plateau State. Hence, the need to determine the trace elements contents of this class of food crops. The trace element content of five different legumes were analysed using inductively coupled plasma-optical emission spectrophotometry (ICP-OES). Statistical analysis was performed on SPSS Version 17.0 and the results expressed as arithmetic mean±SD. The result showed that pigeon peas has the highest trace elements content (Zn = 1338.75±0.40µg/100g; Cu = 212.38±1.47µg/100g; I = 201.24±25.34µg/100g; Se = 1.75±0.14µg/100g), except in Cr where kidney beans is the highest (9.76±7.81µg/100g), followed by soya beans. Mineral contents of crops are directly related to the minerals in the soil on which they were grown. Therefore, the large variations in the trace elements contents of the crops reported here corroborate earlier findings. Further studies on trace elements in staple foodstuffs on the Plateau need to be done in order to compare with their respective RDAs.

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Introduction

Trace elements are metals that occur at concentrations less than 1µg per gramme of wet tissue. Of the various trace elements found in the body, only five (iron, zinc, Copper, selenium, and iodine) of them have been associated with well-characterized deficiency states. Trace elements function mainly as cofactors to enzymes and other metabolic proteins. For example, in the antioxidant enzyme, copper-zinc superoxide dismutase (CuZnSOD) copper provides the catalytic activity while zinc plays a critical structural role (Okoye, 1992; King and Cousins, 2006).

Legumes constitute an important source of dietary protein for a large segment of the world's population, particularly in those countries where the consumption of animal protein is limited by its non-availability or is self-imposed because of religious or cultural beliefs. From time immemorial, cereals and legumes constitute a major portion of animal feeds and staple foodstuffs for man. Legumes are considered potentially the most important plants in the tropics (Rachie and Roberts, 1974), and this group contains many plants that are used for food. Tropical legumes contribute significantly to the staple diet of tropical human populations because of their use as cheap source of protein (Fellows and Nash, 1990). Legumes are important sources of essential nutrients like the B vitamins, carbohydrates, and minerals such as iron, calcium, zinc, and others (Tobin and Carpenter, 1978). Among the legumes, soybeans is considered the best substitute for animal protein as it contains, by far, rich amounts of proteins than any of the other legumes. The amino acid content of soybeans, especially the sulphur-containing amino acids, is particularly impressive (Norman and Benjamin, 2000). *Cajanus cajan* (Pigeon peas) might have been eaten by many without realizing what it is. Pigeon peas has remained a crop grown on small scale, with few large scale efforts been made to produce new varieties with better yields (Odeny, 2007). Two species of cowpeas are commonly found in Nigeria: the black-eyed cowpea (*Vigna unguiculata*) and the red-eyed cowpea (*Vigna sinensis*) with several varieties. The former is considered to be originally domesticated in Africa. Generally, Cowpea is a warm-weather and drought-resistant crop. They are chiefly important as source of protein especially, lysine (Searle et al., 2003). Coffee beans, (*Coffea arabica*) exist in many varieties and are thought to originate in the wild in Ethiopia and America (Rene, 1989). *Phaseolus vulgaris,* commonly called kidney beans, are widely distributed in Nigeria with Enugu State being the major producer. Unlike coffee beans, kidney beans do not contain caffeine and theobromine. In Nigeria, legumes, especially cowpeas, form a valuable and most prominent source of plant proteins in the diet. It is prepared and taken in various forms. The most consumed are the cowpeas.

In this study, we analysed the profile of five trace elements (Cu, Cr, I, Se, and Zn) in five different legumes (cowpea, pigeon pea, kidney beans, coffee beans and soya beans). It is hoped that the information obtained may serve as a basis for deliberate use of some of the legumes as dietary supplements.

Materials and Methods

Materials

Reagents

High purity nitric acid was obtained from the British Drug Houses, Poole, England; and perchloric acid, from Sigma Aldrich Labochemikalien, Germany. All other reagents were of analytical grade.

Equipment

Inductively Coupled-Plasma Optical Emission Spectrometer, ICP-OES, Optima 2000 DV (Perkin Elmer Instruments, Norwalk, CT, U.S.A.). Weighing balances: Adventurer ARC 120 and Adventurer AR2140 both of OHAUS, USA. Pyrex beakers of 50ml capacity, ashless filter papers, and sundry laboratory equipment.

Methods

Samples collection

Samples of the legumes were obtained from the Terminus Market in Jos, except coffee beans (*Coffea arabica*) which was obtained from Vom, near Jos, Plateau State, Nigeria, in the month of June, 2010. The samples (**Plate 1**) were seeds of:

i.	Cowpea (black-eyed)	*Vigna unguiculata*
ii.	Soya beans	*Glycine max*
iii.	Pigeon peas	*Cajanus cajan*
iv.	Kidney beans	*Phaseolus vulgaris*
v.	Coffee beans	*Coffea arabica*

All samples were examined properly for any impurity such as sand and other particles associated with harvested seeds.

Sample preparation and analysis

Samples were treated preparatory to the spectrophotometric analysis as follows: each sample was pounded to a fine form using ceramic mortar and pestle. The pestle and mortar were washed with distilled water and air-dried each time a sample was to be pounded. Two gramme-portion of each powdered sample was digested with the standard digestion solution comprising of a 6:1 mixture of hydrochloric acid, HCl, and perchloric acid, $HClO_4$, according to the methods of Halvin and Soltanpour (1980) and Clegg et. al. (1981), to obtain a white ash. The resultant ash was dissolved in distilled water, quantitatively transferred to a new trace element-free plastic bottle with screw cap, and made up to 20ml with distilled water. The sample was stored in the refrigerator until analysis.

Kidney beans (*Phaseolus vulgaris*)

Coffee beans (*Coffea arabica*)

Pigeon peas (*Cajanus cajan*)

Soya beans (*Glycine max*)

Cowpea, black-eyed (*Vigna unguiculata*)

Plate 1: Legume samples used

Samples were analyzed for chromium, copper, iodine, selenium and zinc on an ICP-OES. ICP-OES operates on the basis of emission of photons by excited atoms of the element in being analysed. When plasma energy is directed on to the analyte sample from outside, the component atoms of the element are excited. When the excited atoms return to the low energy position, they emit radiation that corresponds to the wavelength being measured. The element type is determined based on the position of the photon rays, and the content of each element is determined based on the intensity of the radiation emitted.

Statistical analysis

Statistical analysis was performed using the computer software, SPSS Version 17.0 (SPSS Inc., Chicago). The Student's T-test was the method used. Results are expressed as arithmetic means±standard deviation-SD. The acceptable level of statistical significance for all tests was $p < 0.05$.

Results and Discussions

The results of the analysis are as presented on the Table 1.

From Table 1, there is a variation in the trace mineral contents for each crop. In terms of highest mineral level detected and the mean values, Pigeon peas (*Cajanus cajan*) has the highest (except in Cr content where kidney beans, *Phaseolus vulgaris*, has the highest) followed by soya beans (*Glycine max*), except in Cr and Se contents. In each case, the difference is statistically significant ($p < 0.05$). So, among the leguminous foodstuffs of the areas sampled, Pigeon peas appears to be the richest source of dietary trace elements (based on trace elements content values) followed by soya beans. The contents of copper, iodine and zinc in pigeon peas were 212.38±1.47, 201.24±25.34 and 1338.75±0.40 µg/100g, respectively. These values are high enough to meet up the recommended daily allowances (RDAs) for each mineral, even for food-insufficient families who are more likely to have trace mineral intakes below 50% of the RDA on a given day. Similarly, all the legumes analysed have high iodine contents that could meet up the RDA of iodine of 150µg/day, but not to exceed the tolerable upper intake level (UL) of 1100µg/day. Besides, Hetzel and Clugston (1999) reported that it is rare for diets of natural foods to supply more than 2000µg of iodine per day to cause toxicity.

Mineral contents of crops is known to be related directly to the minerals in the soil on which they are grown (Rengel et al., 1999; Janusauskaite et al., 2013), and Rengel et al. (1999) showed that increasing mineral in nutrient solutions can result in increased mineral concentrations in grains by a factor ten or even more. Chemically, zinc, for example, has some similarities with iron and magnesium, and in plant uptake there can be competition between these elements (Neue et al., 1998). Furthermore, high levels of phosphate in soils can strongly reducethe availability of zinc and other elements with similar chemical properties (Marschner, 1995). Hence, the large variations in trace elements contents of foods reported here. More importantly, for one and the same crop the mineral content can show wide variation (Frossard et al., 2000). Also, flooding of soils as practiced with irrigated rice production may cause deficiencies in micronutrients (Moslehuddin et al., 1997; Neue et al., 1998; Savithri et al., 1999; Salzman et al., 2013; Barrett and Bevis, 2014).

Reports on trace minerals levels in Nigerian foods are very limited. This led to insufficient database for the contents of trace minerals in foods. To solve this problem the International Institute of Tropical Agriculture, IITA, conducted a survey between 2001 – 2003 (Maziya-Dixon et al., 2004) to create awareness on the micronutrient deficiencies in Nigeria with emphasis on the trace elements zinc, iron and iodine, and the vitamins, A, D among others. The composition table of the United states Department of Agriculture, USDA, (2011), provides a comprehensive database for trace elements and vitamins. But mineral contents of foods differ per region, and the rate of mineral utilization is also different according to ethnic eating pattern. Therefore, one cannot rely on foreign data to evaluate mineral contents of our foods.

Conclusion

In this study, we found that trace element contents of legumes analysed varied widely even within the same species. Despite this variation each of the legumes contained appreciable amounts of most of the trace elements analysed that could meet up the RDAs for the particular element. However, while there is still insufficient data available in Nigeria on the contents of trace elements in food items, this study will contribute towards promoting further studies on trace minerals.

Table 1: Trace element content of some legumes consumed in Plateau State, Nigeria

	Trace Element Content (µg/100g)*				
Sample	Cr	Cu	I	Se	Zn
Cowpeas	1.72±0.024	11.78±0.30	146.75±7.26	1.44±0.29	353.50±4.73
Kidney beans	9.76±7.81	11.66±0.04	155.00±20.66	0.11±0.01	210.75±0.48

Pigeon peas	3.11±0.00	212.38±1.47	201.24±25.34	1.75±0.14	1338.75±0.40
Soya beans	2.09±0.02	14.40±0.80	159.75±12.01	0.55±0.09	437.50±2.41
coffee beans	1.70±0.01	8.20±0.30	128.63±3.18	1.45±0.21	101.87±0.69

* Tabulated data are means±SD of 3 determinations per sample

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