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Evaluation of Trace Elements and Total Antioxidant Status in Nigerian Cassava Processors

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Abstract: The consumption and export cassava or cassava product is on the increase, thus more Nigerians are involved in the planting and processing of cassava stems and tubers respectively. Tropical ataxic neuropathy (TAN) and diabetes Mellitus (DM) are among the cassava-cyanide induced conditions in rural Nigerians that engaged in processing and consumption of cassava products. TAN and DM are associated with certain trace elements, therefore this study determines the levels of trace elements (Mg, Fe, Zn, Mn, Cu, Cr, Cd, Pb) and total antioxidant (TAS) in 36 Nigerian cassava processors and 24 controls using spectrophotometric methods. The mean levels of Mg, Pb, Cd, Cr and Cu were not significantly raised in cassava processors compared with the controls. Also, the mean levels of essential trace elements such as Se, Zn, Fe, Mn and TAS were not significantly reduced in cassava processors compared with the controls. Fairly raised levels of toxic metals (Pb and Cd) and reduced levels of nutritionally essential trace elements (Se, Fe and Zn) call for future concern about the health status of long-time cassava processors.

Key words: Cassava, micronutrients, Nigeria and neuropathy

Introduction

Cassava is the third most important food source in the tropics after rice and maize and is the staple food of at least 500 million people (Cock, 1985). Cassava is easy to grow, yields well in good conditions and even in poor soils. The roots are very starchy and the young leaves are a good source of protein (Bradbury and Holloway, 1988). Because of the perceived agricultural advantages of growing cassava and increasing population pressures, its usage is being extended.

As a defense mechanism against attack by predators, cassava produces two cyanogenic glucosides, viz: linamarin and a small amount of methyl linamarin. These cyanogens are distributed widely throughout the plant, with large amounts in the leaves and the root cortex (skin layer) and generally smaller amounts in the root parenchyma (interior). The high cyanide parenchyma roots must be processed before consumption to reduce the amount of toxic cyanogens to a safe level. The World Health Organization (WHO) has set the safe level of cyanogens in cassava flour at 10ppm (FAO/WHO, 1991) and the acceptable limit in Indonesia is 40ppm (Diazuli *et al.,* 199). The major stages of cassava processing to reduce cyanide level includes peeling, grating, water soaking, compressing and roasting (Oke, 1994). These are done manually in Nigeria, thus exposing cassava processors to toxic effects of cyanogenic glycosides which enter the body through inhalation, skin penetration and ingestion (Oke, 1994).

Large amounts of cyanogens may cause cyanide poisoning with symptoms of vomiting, nausea, dizziness, stomach pains, weakness, headache and diarrhea and occasionally death (Akintonwa *et al.,* 1994). Cyanide intake from cassava exacerbates goiter and cretinism in iodine deficient areas (Delange *et al.,* 1994) and is almost certainly the cause of "Konzo" in Eastern, Central and Southern Africa. "Konzo" is an irreversible paralysis of the legs of sudden onset, which occurs particularly in children and women of child bearing age (Clioff *et al.,* 1997). Tropical ataxic neuropathy (TAN) is a chronic condition of gradual onset that occurs in older people who consume a monotonous cassava diet. It causes loss of vision, ataxia of gait, deafness and weakness (Oke, 1994, Onabolu *et al.,* 2001).

Neurologic disorders and trace elements are closely related. Copper is an essential micronutrient necessary for the hematologic and neurologic systems, manganese exposure reportedly may have an adverse effect on CNS function and mood (Tan *et al.,* 2006) while iron deficiency has been reported to have a role in brain development and the pathophysiology of restless legs syndrome. Iron accumulation has been related to some neurologic disorders such as Alzheimer disease, Parkinson disease, type I neurodegeneration with brain iron accumulation, and other disorders (Sadrzadeh and Saffari, 2004). Cassava-cyanide induced TAN, "Konzo", goiter and cretinism was reported to be prevented by processing cassava with methods that will reduce the cyanide content (Oke, 1994).

Cyanide was reported to induce high concentration of Zn in the liver probably affecting the blood level of this metal (Behari *et al.,* 1981). Cr is known to potentiates insulin action (Wennberg *et al.,* 1994).One of the mechanisms

Table 1: Levels of trace metals in cassava processors compared with the controls

	n	Mg (mg/L)	Fe (µg/dl)	Zn (mg/L)	Mn (ng/dl)	Cu (µg/dl)	Cr (µg/L)	Cd (µg/L)	Pb (µg/dl)	Se (µg/dl)	TAS (µg/dl)
C	26	4.6±1.3	70±7.8	10±14	64±7	57±8	57±10	60±10	61±11	68±8	2.7±0.9
C.P	34	5.0±1.5	68±7.3	9.7±17	63±6	59±7	61±7	62±13	63±9	67±7	2.2±1.0

C = Controls. C.P = Cassava processors

by which cyanide induces the neurotoxic effect is by generation of free radicals which is neutralized by anti-oxidants (Montegomery, 1995). So far, TAN and DM are physiological disorders among rural Nigerians that are linked to cassava-cyanide consumption.

Since cassava-cyanide induced TAN and DM have been linked with certain trace elements, the present study hypothesized that cassava cyanide may affect the levels of trace elements and anti-oxidants. In the present study, the levels of plasma trace elements and TAS were determined in cassava processors compared the controls (non - processors and minimal consumers). This will provide one of the bases of cassava cyanide poisoning and thus supplementation of deficient trace elements will be recommended.

Materials and Methods

Participants: Thirty-four subjects who had been involved in all stages of cassava processing for between 10-18 years were selected for this study. The site of cassava processing is in Ibadan metropolis, Oyo State, Nigeria. Twenty-six (age and sex matched) controls were recruited from members of staff/student of University College Hospital, Ibadan, Oyo State, Nigeria. Informed consent was obtained form each subject before collecting blood samples. About 10ml of blood was collected from each of them into a sample bottle containing lithium heparin. The plasma was separated into another clean container before analysis.

Determination of plasma levels of trace metals: Plasma levels of these elements were determined with flame atomic absorption spectrophotometer (AAS) using a direct method as described by Kaneko (1999). The method is based on the principle that atoms of the element when aspirated into AAS, vaporized and absorbed light of the same wavelength as that emitted by the element when in the excited state.

Determination of plasma level of total antioxidants: Total antioxidant was determined by a method of Koracevic *et al.* (2001). A standardized solution of Fe-EDTA complex reacts with hydrogen peroxide by a Fenton - type reaction, leading to the formation of hydroxyl radicals. These reactive oxygen species degrade bengoate, resulting in the release of thiobarbituric acid reactive substance (TBARS). The rate of inhibition of colour development is proportional to the concentration of anti-oxidative activity.

Results

Table 1 shows the mean levels of trace metals and TAS in cassava processors compared with the controls. The mean levels of Mg, Pb, Cd, Cr and Cu were not significantly raised in cassava processors compared with the controls. Also, the mean levels of essential trace elements such as Se, Zn, Fe, Mn and TAS were not significantly reduced in cassava processors compared with the controls.

Discussion

Previous studies have revealed that while the finished products of cassava processing may be safe for human consumption, the cassava processors are exposed to cyanide at different stages of processing. Therefore, cassava processors are at higher risk of side effects of cassava cyanide poisoning. The role of trace metals in occupational exposure has been widely studied. But to the knowledge of the authors, the assessment of trace elements in Nigerian cassava processors is neglected. Trace elements are required in small concentrations as essential components of biological enzyme systems or of structural portions of biologically active constituents. Iron is an important constituent of succinate dehydrogenase as well as a part of the heme of hemoglobin, myoglobin and the cytochromes (Chandra, 1990). Copper is present in many enzymes involved in oxidation (tyrosinase, ceruloplamin, amine oxidase, cytochrome oxidase) and manganese is a part of enzymes involved in urea formation, pyruvate metabolism and the galactotransferase of connective tissue biosynthesis (Chandra, 1990). In addition to its role in vitamin B_{12}, cobalt is also a cofactor of enzymes involved in DNA biosynthesis and amino acid metabolism. Chromium is needed for growth of rats and its deficiency leads to a reduced life-span, corneal lesions, and interference with insulin action producing a diabetic state with removal of glucose from the blood at a rate that is one-half that of animals on a chromium-containing diet (Wennberg , 1994).

Immune cells, like all other types of cells, require an adequate supply of trace elements to express and preserve the structure and function of key metalloproteins that participate in housekeeping processes such as energy production (iron and copper) and to protect the cell against highly toxic reactive oxygen species (copper, zinc and iron). Moreover, the continuous generation of immune cells in bone marrow and the clonal expansion of lymphocytes in response to antigenic stimulation require the availability of sufficient iron and zinc (Chandra, 1990).

A previous study showed that chemicals, environmental pollutants and cellular activities lead to generation of reactive oxygen species and free radicals which are removed by antioxidant system (Montegomery, 1995). Our present study showed no significant differences in the levels of trace elements in cassava processors compared with the controls. Therefore, it may be concluded that:

1: There is no substantial cassava-cyanide induced free radical generation in our test subjects.
2: Although, cassava processing has no significant adverse effects on the levels of trace elements and TAS of cassava handlers but raised levels of heavy metals (Pb and Cr) and reduced levels of nutritionally essential trace elements (Se, Fe and Zn) and TAS calls for future concern about the health status of long-time cassava processors.

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