Toxic and Essential Metals in Staple Foods Commonly Consumed by Students in Ekiti State, South West, Nigeria.

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Abstract

Humans are exposed to Toxic Metals(TMs) and Essential Metals (EMs) through different sources but the most important are staple foods. Exposure to TMs and EMs may bring about harmful and beneficial effects respectively. Previous studies on the assessment of TMs and EMs levels in staple foods commonly consumed in Nigeria were focused on general populace while less attention had been paid to staple foods consumed by students within University campuses. Hence, this study was designed to determine the concentrations of selected TMs and EMs in staple foods commonly consumed by University students given the peculiar nature of their feeding habit.

A structured questionnaire to obtain information on the kinds of staple foods consumed was administered to 200 consenting students of Ekiti State University, Ado Ekiti. Some samples of staple foods were identified. The identified staple foods were purchased from food vendors and local market in the research location and sorted into categories. Staple foods were oven dried at 105 °C for 24 hrs and pulverized. One gramme each of staple food was digested using dry ashing. The digests were analysed for Zinc, Copper, Lead and Cadmium using atomic absorption spectrophotornetes, Data were subjected to descriptive statistics and compared with permissible limits as set by FAOIWHO guidelines for food standard

Questionnaire indicated the followings: Spaghetti, jollof rice, rice with stew, wheat with soup, white and red beans, akara (beans cake), moin-moin, melon, groundnut, yam, amala,(cassava and yam flour), garri (fried cassava), eba, potato as staple foods usually consumed by the University students. The staple foods were categorized into cereals, legumes and tubers   respectively. In the staple foods, the mean concentration\ (mg/kg) of zinc, copper, Cadmium and Lead ranged respectively as follows: 11.1±5.34-16.6±11.9, 3.70±3.30-5.60±5.10, 0.02±0.02-0.28±0.23 and 0.10±0.10-0.22±0.17.respectively.Hightest concentrations (mg/kg) of zinc (16.6±11-9) and cadmium (0.28±0.23) were found in cereals while the highest concentration of copper (5.60±5.10) and lead (0.22±0.17) were found in legumes and tubers respectively. The concentrations of zinc, copper, and lead were within the permissible limits set by FAO/WHO guildelines for food standard while cadmium concentration in cereals such as rice and wheat were above the permissible limits

Staple Foods consumed by the University students were relatively safe in terms of toxic and essential metals contamination except cereals whose cadmium level exceeded the permissible limit.

Keywords: staple foods, essential and toxic metals, university students.

1. Introduction

Foods are important for human survival. They may contain essential metals and toxic metals which can either be beneficial or hazardous to man. (WHO, 2007).

Metals in foods are to pay attention to, because of their essential benefit and toxic effects on human health. The ranges between beneficial and toxic levels are usually small. High concentrations of lead can cause irreversible brain and neurological damage, seizure, coma and death if not treated immediately.

In adults, lead is very detrimental to the cardiovascular system, Exposure to it regularly may cause high blood pressure and are at increased risk for myocardial infarction and stroke. ATSDR (2011). Consumption of

cadmium even at lower levels over a long period of time can lead to a build up cadmium in the kidney causing a serious damage. It is also carcinogenic to human as determined by the International Agency for Research on cancer. (GEMS, 2007).

Copper plays an important roles in cholesterol metabolism and is also needed for the neuron transmitters while zinc helps in physiological and metal biological processes of many organs in the body.(NML, 2001). Though they may be toxic at high level of exposure. (Jorhem and Sundstroen, 1993).

However, the incidence of food related diseases is becoming rampant among the youths most especially the university students within South-West State, and there is a paucity of information on the level of Essential and Toxic Metals in food consumed by students especially in Ekiti state, of Southwest Nigeria.

Therefore the aims of this research study was to assess the level of essential metals and toxic metals exposure through staple food consumption by the students, in Ekiti state, South-West, Nigeria and the public health impact of the exposure.

2. Materials and Methods

2.1 Sampling and Sampling Record

Based on the nutritional importance of this study, standardized questionnaire designed was used as an instrument to find out kinds of staple foods commonly consumed by the students in Ekiti states southwest Nigeria. Prior to the distribution of the questionnaire, the validity of the questionnaire was determined. The questionnaire designed includes the following data information: Age, sex, weight of the respondent state of origin, location, father's occupation, mother's occupation, guidance's occupation, self occupation/self sponsor, and commonly consumed by the respondent staple food.

In addition the questionnaire also indicates how often these foods were consumed and the frequent ailment affecting the respondents. The questionnaires were distributed among the two hundred volunteered students from the representative University.

After the collection of the questionnaire from the respondents, the reliability of the instrument from the pilot study was determined to be 0.76 by using Alpa cornbach coefficient.

2.2 Collections of Samples

Questionnaire indicated the followings: Spaghetti, jollof rice, white rice, wheat, palp, semovita, indomie, white and red beans, beans cake (akara), moin-moin, melon, groundnut, yam, amala (Cassava and yam Flour),(fried cassava) Eba, potato and fufu as staple food items usually consumed by the students in Ekiti State. The staple foods were categorized into cereals, legumes and tubers. The identified staple foods were purchased from food vendors in the research locations.

2.3 Sample Preservation and Pretreatment for the Solid Food Items

Each food sample (e.g. Yam, rice and beans) was put into clean centrifuge tubes, air-dried for about 2 – 3 days in a clean laboratory environment and further oven dried at $105^{o}C$ for 24 hour and pulivensed.

2.4 Sample Digestion and Metal Analysis

One gramme each of the solid staple food was digested using dry ashing. The digest were analysed for zinc, copper, lead and cadmium using Atomic Absorption Spectrophotometer (AAS, Perkin Elmer Model 2130). Data were subjected to descriptive statistics. (AOAC, 2003).

2.6 Quality Assurance and Quality Control

Quality assurance and quality control during the course of this study were ensured by meticulously following written procedures for sampling handling both on the field and in the laboratory, and all instruments and equipments were calibrated before use. (AOAC, 1996).

3. Result and Discussion

Heavy metal concentrations of the food samples in mg/kg were reported in Table 1.

Table 1. Heavy Metal Concentration (mg/kg) of Food Items in mg/kg

Food items	Heavy Metal (mg/kg)			
	Zn	Cu	Cd	Pb
Cereals /Cereal product and others				
Spaghetti	3.63	2.80	0.16	0.13
Jollof Rice	10.0	5.00	0.10	LT DL
Rice with stew	10.9	4.00	0.47	LT DL
Rice with beans & fish	14.7	12.4	0.50	0.30
Palp with milk (Solid)	23.0	3.30	0.40	0.20
Wheat with soup	39.5	3.40	0.20	0.22
Semovita with soup	18.0	6.90	0.30	0.03
Indomine	29.4	5.50	0.25	LT DL
Ordinary palp	0.43	2.40	0.20	LT DL
Semovita	11.0	1.30	0.20	0.10
Legumes/Legumes product with others				
Beans (White)	3.48	1.05	0.01	0.01
Beans with plantain	25.4	6.00	0.28	0.15
Akara ball	34.9	4.50	0.07	0.16
White bean with rice & fish	11.0	4.70	LT DL	0.20
Moinmoin	8.67	9.48	0.35	0.01
Beans with garri	13.8	3.46	LT DL	0.25
Melon	18.9	2.34	0.01	0.10
White beans, rice with palm oil	7.22	4.50	0.05	LT DL
Groundnut	14.0	17.6	0.26	0.05
Sweet Beans (Red)	23.0	2.01		LT DL
Tubers/Tubers product with others				
Yam	9.25	4.50	0.01	0.03
Pounded Yam With Melon	18.1	8.13	0.05	0.05
Amala (Cassava Flour)	11.3	3.84	0.03	0.14
Amala (Yam Flour)	9.20	2.15	LT DL 0.02	0.30
Eba With Melon	6.10	3.45	0.03	0.30
Fried Cassava (Garri)	5.21	1.07	LT DL 0.02	0.30
Yam With Oil	11.5	2.95	0.05	0.30
Yam With Egg	16.0	6.43	LT DL	0.30
Potato	13.0	0.82		0.30
Fufu	6.26	1.32		0.15

LTDL $\Rightarrow$ Less than detection limit

Detection Limits for the metals

Cu $\Rightarrow$ 0.02

Zn $\Rightarrow$ 0.04

Cd $\Rightarrow$ 0.0009

Pb $\Rightarrow$ 0.005

Heavy metal uptake in staple foods could be from the soil of the cultivated area, the atmospheric condition and partly from the irrigated water. In this studies heavy metal concentration were determined by atomic absorption spectroscopy in mg/kg.

The result of concentrations of the essential metals (Cu and Zn) and toxic metals (Pb and Cd) in the staple food samples given in Table 1 shows that the metal concentrations were within the following range: Zn (0.43 – 39.5), Cu (0.82 – 17.6), Cd (LTDL - 0.50) and Pb (LDTL - 0.30) all in mg/kg. Highest level (mg/kg) of zinc (39.5), copper (17.6), and cadmium (0.50) were observed in wheat, beans and rice respectively. Lead determination was shown significantly high in yam, Amala (yam and cassava flour), Garri (fried cassava), and potato.

Table 2. Average levels (mg/kg) of Zinc, Copper, Cadmium and Lead in various food groups

Food items	Zn		Cu		Cd		Pb	
	Mean ±S.D	Range	Mean ±S.D	Range	Mean ±S.D	Range	Mean ±S.D	Range
Cereals Products (A)	16..6±11.9	0.43- 39.5	4.70±2.99	1.30-12.2	0.28±0.23	0.06-0.50	0.10±0.15	LTDL - 0.30
Legumes products with others (B)	16.1±10.5	3.48- 34.9	5.60±5.10	1.05-17.6	0.10±0.10	LTDL-0.50	0.10±0.10	LTDL -0.25
Tubers product with others (C)	11.1±5.34	6.26-18.1	3.70±3.30	0.82-8.13	0.02±0.02	LTDL-0. 50	0.22±0.17	0.03-0.30

The mean concentration (mg/kg) of zinc, copper, cadmium and lead ranged respectively as follows: 11.1±5.34–16. 6 ±11.9, 3.70 ±3.30– 5.60±5.10, 0.02 ± 0.02–0.28 ± 0.023 and 0.10 ± 0.10– 0.22 ±0.17 respectively.

Highest concentrations (mg/kg) of zinc (16.6±11.9) cadmium (0.28± 0.023) were found in cereals while the highest concentrations of copper (5.60±5.10) and lead (0.22±0.17) were found in legumes and tubers respectively. The concentration of zinc, copper and lead were within the permissible limits set by FAO/WHO guidelines for food standard while cadmium concentrations in cereals such as rice and wheat were above the permissible limits. Recommended permissible limit of Zinc, copper, lead, and cadmium are 99.0mg/kg, 40.0 mg/kg, 0.30 mg/kg and 0.20mg/kg respectively as set by FAO/WHO (2001).

Percentage recovery for the metals Zn, Cu, Cd and Pb obtained were 92.2%, 94.3%, 96.0% and 98.2% respectively. This result shows that the error in the concentration of the toxic and essential metals found in the food samples were within the acceptable limit of 100 ±20%.

Table 3. Comparison of Cu and Zn levels (mg/kg) in some Nigerian foods with levels in similar foods in other countries

Food	This Study		Nigeria[a]		Nigeria[b]		Sweden[c]		East Asia[d]		USA[e]		USA[f]	
	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn
Beef	1.20	7.00	0.89	48.0	-	-	1.60	23.5	1.60	22.0	7.24	81.7	0.58	10.5
Beans	2.01	23.0	6.87	42.7	1.30	0.75	5.60	27.0	8.80	11.0	2.72	14.0	3.08	29.1
Sugar	0.10	1.80	0.33	0.60	-	-	0.23	0.06	-	-	0.09	0.10	0.29	2.85
Potato	0.82	13.0	0.72	3.00	-	-	0.72	3.00	2.30	0.30	0.64	2.10	0.60	7.66
Pork	-	-	2.87	30.2	-	-	0.90	34.0	1.90	25.0	0.95	30.8	0.80	-
Corn	3.35	20.4	2.33	33.4	1.30	8.00	-		1.60	14.0	0.48	6.10	0.38	4.39
Yam	4.50	9.25	4.73	10.0	2.20	2.70	-		-	11.0	-	-	-	-
Rice	4.00	10.9	1.53	4.93	1.40	3.00	-		2.30	15.0	0.73	5.70	1.90	9.35
Bread	0.88	1.08	0.60	2.93	-	-	-		-	-	1.11	7.20	1.32	8.20
Egg	-	-	1.13	6.87	-	-	-		0.50	9.0	0.64	14.6	0.80	12.3

Table 3 shows comparison of Cu and Zn levels mg/kg in some Nigerian foods with levels in similar foods in other country.

Zinc concentration for rice (10.9 mg/kg) in this study is close to the value (9.35 mg/kg) obtained by Hussean and Bruggeman (1997) in U.S.A. The Zinc concentration (9.25mg/kg) for yam in this study is very to the value (10.0 mg/kg) obtained by Onianwa et al. (2001) in Nigeria. Also Copper level (4.50mg/kg) in yam in this study is very close to the copper level obtained for yam (4.73mg/kg) in Nigeria by Onianwa et al. (2001). Copper level (0.82 mg/kg) in potato (tuber product) in this study is very close to the copper level (0.72 mg/kg) obtained for potato by Onianwa et al. (2001) in Nigeria.

Zinc level (23.0mg/kg) in beans (legume products) in this study compares well with zinc level (27.0mg/kg) in beans obtained in Sweden by Jorhem and Sundstroen (1993).

4. Conclusion and Recommendation

Conclusion: Zinc, copper, cadmium and lead were identified as contaminant in staple foods that are commonly consumed by university students in Ekiti State in this current study. Most items consumed by the students were relatively safe in terms of essential and toxic metal contamination, except for cereal products the most frequently consumed staple food by the students in the research area as indicated in the questionnaires which are contaminated, because the cadmium level exceeded the safe limit.

Recommendation

Based on the findings of this study we could see that highly toxic metals like cadmium etc. were found in some of the staple food items consumed by the students in Ekiti State which could have long term effect on human health. To safeguard this undesirable effect the followings are recommended

1. The attention of the Local, State, and Federal Ministry of Health in Nigeria should be drawn to presence of toxic metals in different kinds processed and unprocessed staple food items base on the evidences provided by this study

2. The result of this research should also serve as a point of reference for enacting regulators and laws that control inputs of toxic metals in food during plantation and processing periods

3. Public awareness especially to the students on the potential danger of frequent consumption of metal contaminated food should be created.

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APPENDIX

QUESTIONNAIRE ON

TOXIC AND ESSENTIAL METALS IN STAPLE FOOD ITEMS AND DRINKS COMMONLY

CONSUMED BY STUDENTS IN EKITI STATE OF SOUTHWEST NIGERIA

This questionnaire is designed to find out kinds of staple foods that are commonly consumed by students in Ekiti state of Southwest Nigeria.

I shall be grateful if the correct information required is given.

(1)   Age: _____

(2)   Sex: _____

(3)   Weight: _____

(4)   State of Origin: _____

(5)   City /Community: _____

(6)   Father's Occupation:_____

(7)   Mother's occupation: _____

(8)   Common Staple food intake   [   ]   [   ]   [   ]
                                    Morning   Afternoon   Night

(9)   How often do you eat the staple food?   Often [   ]   Seldomly [   ]

(10)   Do you have a particular ailment that usually disturbs you? Yes [   ]   No [   ]

(11)   If yes, indicate   [   ]   e.g. (headache, stomach ache, constipation fatigue and diarrhea

(12)   If yes how often? Very often [   ]   often [   ] seldomly [   ]