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Trace Heavy Metal Levels of Some Bouillon Cubes, and Food Condiments Readily Consumed in Nigeria

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Abstract: The Fe, Zn, Pb and Cd contents of bouillon cubes and other food condiments readily consumed in Nigeria were determined by atomic absorption spectrometry after acid digestion with 2:1 HNO_3/$HClO_4$.The level of Pb in the samples were generally low and below detection limit (<0.02µg/g).The levels of the other metals ranged from 3.60-3.65µgCd/g, 3.65-8.95µgFe/g, and 1.60-4.40µgZn/g for bouillon cubes; 3.90-5.05µgCd/g,11.05-32.70µgFe/g,and 3.0-3.70µgZn/g for chicken seasonings; ND-1.80µgCd/g, 32.35-320.85µgFe/g , and 13.65-90.0µgZn/g for curry powders; 0.85-4.80µgCd/g, 32.70-73.20µgFe/g and 3.70-21.25µgZn/g for beef seasonings; 1.10-1.15µgCd/g, 92.35-419.05µgFe/g, and 25.95-48.10µgZn/g for thyme; and 0.80-4.90µgCd/g, ND-50.60µgFe/g and 3.4-22.55µgZn/g in mixed spices. Zn levels correlated strongly (R^2 = 0.77) with Fe levels in the samples. The low level of the toxic metals, Pb and Cd, indicates that these products meet the safe limits specified by most food standards. The frequency and regularity of consumption and popularity of these products demands periodic surveillance to avoid contamination. This result will complement available data on food composition in Nigeria.

Key words: Bouillon cubes, lead, heavy metals, food condiments, Nigeria

Introduction

Trace metals composition of foods is of interest because of their essential or toxic nature (Onianwa *et al.,* 1999). The accumulation of heavy metals can have middle-term and long term health risks, and strict periodic surveillance of these contaminants is therefore advisable (Cabrera *et al.*, 1995). Micronutrients constitute a small fraction of the entire diet but play important roles in different metabolic processes (Akhter *et al*., 2002).

Food composition data is important in nutritional planning and provides data for epidemiological studies (Bruce and Bergstrom, 1983). Environmental pollution is the main cause of heavy metal contamination in food chain. The trace metal contents of individual foods varies and is dependent upon the trace metals introduced in the growing, transport, processing and fortification of food (Anderson *et al.,* 1992). The other technological processes used to bring the food to the consumer can significantly increase the total trace metal contents of the food (Cabrera *et al.*, 2003).

Wide variations in concentrations of trace metals have been reported in bouillon cubes, mixed spices, natural plant spices and nuts (Akpanyung, 2005; Garcia *et al.,* 2000; Satter *et al.*, 1989; Ansari *et al.*, 2004). Natural food spices such as pepper and mustard have been reported to contain significant quantities of some trace metals (Gupta *et al.*, 2003). These trace metals in spices and medicinal plants play vital role as structural and functional components of metalloprotiens and enzymes in living cells (Ansari *et al.*, 2004). Zinc is a metal with great nutritional importance and is particularly necessary in cellular replication and the development of the immune response (Salgueiro *et al.*, 2002). Similarly iron plays an essential role in many metabolic processes including oxygen transport, oxidative metabolism, and cellular growth. In human beings, it is absorbed primarily in the duodenum, transported through the blood stream and extracellular fluid bound to transferrin, and stored intracellularly predominantly in the form of ferritin (Lynch, 1997). Environmental pollution is the main cause of heavy metal contamination in the food chain and Pb and Cd are two potentially harmful metals that have aroused considerable concern (Cabrera *et al.*, 2003).

In Africa, the current quest for easy to prepare or fast foods has brought with it a progressive loss of important components of the African food culture. The African's richly enormous variety of food spices and condiments are today gradually being replaced by the large number of bouillon cubes in the market (Smith, 1995). Dawadawa, an alkaline fermentation product of African locust beans (*Parkia biglobosa*) has been an important food condiment in the West/Central African region, and is used to enhance or intensify meatness in soups, sauces and other prepared dishes. The preservative and flavour characteristics of this type of fermented foods are derived in part from the liberation of ammonia and increased pH, concurrent with protein hydrolysis to free amino acids and peptides (Beaumont, 2002).

Bouillon cubes are taste enhancers and are added to foods to augment the taste properties of food

(Akpanyung, 2005). The major active ingredients in bouillon cubes are salt (NaCl) and monosodium glutamate (MSG). Other raw material used include soyabeans, locust beans, onion, tomato, hydrogenated palm oil (HPO), caramel, hydrolyzed plant/ vegetable protein and natural spices (RMRDC, 2003). Oxidative and hydrolytic degradation products of the lipid components of bouillon cubes indicates that the fats blended into the bouillon cube preparation were highly variable and were mainly made up of refined vegetable oils that had undergone hardening by hydrogenation in most cases (Caponio *et al.*, 2002; 2003). Available data indicates that the bouillon and seasoning/culinary sub-sector of the food, beverages and tobacco sector in Nigeria had a favorable growth over the period 2000-2003,with production output increasing by 50-100%,with approximate average current capacity utilization of 87% and installed capacity of 55,000metric tons (Table 1) (RMRDC, 2003). Much of the raw materials are locally produced while salt and MSG, the primary ingredients are still being imported (Table 2). Increased output is expected as the major manufacturers are making substantial investment in cubing and wrapping machinery with the replacement of some old equipments with faster and more efficient ones (RMRDC, 2003).

Earlier studies of bouillon cubes in Nigeria focused on the biochemical, proximate and essential mineral composition of these products.(Akpanyung, 2005; Elemo and Makinde, 1984).The proximate composition analyses of bouillon cubes consumed in Nigeria (Table 3) reported a high average ash content of 57.90% (Range 48.15-63.20%). This indicates a high inorganic (mineral) content of these products.

The aim of the present study was to determine the trace metals composition of bouillon cubes, spices and food condiments readily consumed in Nigeria. Two toxic metals (Pb and Cd) and two essential micronutrients (Fe and Zn) were determined to assess human intake of these metals from the consumption of foods prepared with these food condiments.

Materials and Methods

Various food taste enhancers (seasoning and culinary condiments) and spices including bouillon cubes, curry powder; dried thyme; mixed spices; natural (unprocessed) spice, uziza (name in Ibo language of Nigeria); and table salt were purchased from the open market in Umuahia, Southeastern Nigeria. A total of twenty samples were collected and grouped into eight groups/classes based on the active flavoring agent, nature or type of sample (Table 4). These food condiments represent the most widely used taste enhancers in Nigeria. The samples were carefully opened and dried to constant weight.1g sample was digested with 20mL of 2:1 HNO_3/$HClO_4$ (AnalaR grade), and heated until evolution of white fumes. Where necessary more acid mixture was added and the sample digested until evolution of white fumes marking the end of the digestion process. The digests were filtered into standard 50mL volumetric flask and made up to mark with distilled water. This was subsequently analyzed for Pb, Cd, Zn, and Fe by air-acetylene flame atomic absorption spectrometry (BUCK Scientific, Model 200A) by the standard calibration technique. Calibration standards were prepared by dilution of the high purity commercial BDH metal standards for atomic absorption analysis. Adequate quality assurance measures were carried out to ensure reliability of results. Glassware were properly cleaned and reagents (HNO_3, $HClO_4$ and distilled water) were of analytical grade. Spikes and blanks were also introduced. Results reported are average of duplicates.

Results and Discussion

The mean (±SD) and range of the trace metals contents of the culinary and seasoning products studied is shown in Table 5. The overall mean Cd, Fe and Zn contents of the samples studied are 2.78±1.72µg/g (Range ND-5.05µg/g); 75.40±116.79µg/g (Range ND-419.05µg/g) and 12.08±12.44µg/g (Range 1.00-48.10µg/g) respectively. Logarithm normalization of the results gave geometric mean values of 2.38µg/g; 35.81µg/g and 7.13µg/g for Cd, Fe and Zn respectively. The Pb content of the samples studied were generally below the detection limit of the technique used (0.02µg/g). Higher mean values was observed for Fe in the various sample groups compared to Zn and Cd. The very low levels of the toxic metal, especially Pb in the sample indicates that these products meet the safe limits for toxic elements specified by most food standards. The relatively high levels of the essential elements Fe and Zn of our study corroborates the result of Onianwa *et al.,* (1999) and reflects the normal composition expected of plant-derived products, which most of the samples are. Plant foods and plant-derived foods contain Fe in the form of metalloprotiens, plant ferritins, Fe present in the sap, and Fe complexed to structural components or storage compounds predominantly as phytates. In addition, food may contain contaminant inorganic Fe salts such as ferric oxides and hydroxides or Fe compounds added during processing to fortify the food (Lynch, 1997).

The highest Cd concentration was found in chicken seasoning (5.05µ/g). The mean values for Fe and Zn for thyme were the highest compared to the other sample groups. The mean Fe and Zn concentration of the various sample groups is in the order thyme: > curry > beef seasoning > mixed spices > bouillon cubes.

New evidence from nutritional studies demonstrates the important role of micronutrients in the prevention of various diseases. Hence the inflow of new information relating to dietary characteristics from different

Table 1: Industrial Performance of the Bouillons/Seasoning sub-sector in Nigeria for the period 2000-2003 (metric tonnes/Liters)

Sub-sector	Product/ Brand name	Installed capacity	Current capacity	Capacity utilization (%)
Bouillons	Doyin cube*	-	575,279 cartons	82.78
and	Maggi cube(s)*	23590.75 Mt	19529.50Mt	82.79
seasoning	Royco cube*	31,500Mt	30,500Mt	95.24
(culinary)				

*Registered Trade Names

Table 2: Raw material demands of the Bouillons/Seasoning sub-sector in Nigeria for the period 2000-2003 (metric tonnes/Liters)

Sub-sector	Raw Material	Industrial Demand	Local Production
Bouillons and	PVD salt	15,096	24.275
seasoning (culinary)	Palm stearin	817	17,548
	Soya beans	1,775	3,743

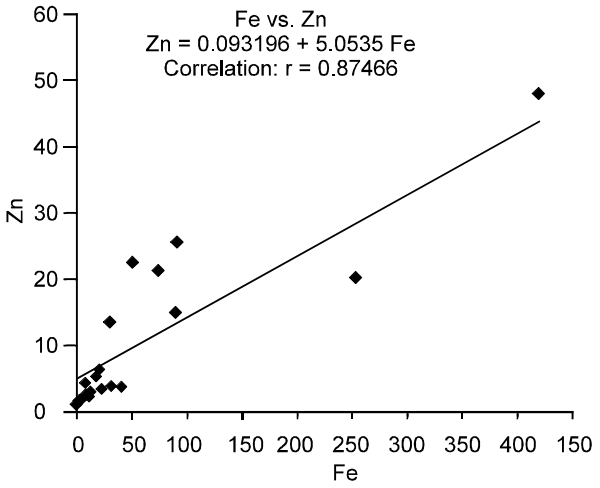

Fig. 1: Regression relationship between the iron and zinc concentrations (µg/g dry weight) in food condiments from Nigeria

population groups (Natera *et al*., 2002).The observed low levels of Zn and Fe in the common salt sample is expected as there is no program of micronutrient fortification of table salt with Zn or Fe in Nigeria. A new awareness in the country has helped the salt iodization program of the country. The Cd content of the salt sample (4.5µg/g) may indicate contamination from the production, packaging or distribution of the product.

Correlation study of our result indicates only a strong positive correlation (r = 0.87) between Zn and Fe (Fig. 1) with a derived regression equation of the form:

Zn (µg/g) = 5.0535 Fe (µg/g) + 0.093196.

The above regression model obtained can explain approximately 80% of the variation in our data (R^2 = 0.77). Strong positive correlation were also observed for the levels of Fe and Zn in the bouillon cubes (r = 0.64), curry powder (r = 0.91), and chicken seasoning (r = 0.89). The observed variability in the levels of Cd within a sample group and between groups may reflect the presence of Cd contamination in the raw materials used during production or secondary contamination from different technological processes or even in the product distribution network. Coloring agents often contain Pb and Cd salts and may contribute to food contamination (Cabrera *et al.*, 1995). The high level of especially Fe in the curry powder, beef seasoning and chicken seasoning may be as a result of intentional fortification of these products with Fe by the industries or from the cumulative contributions of the raw materials used.

Human intake of a given element has been observed to be directly or indirectly related with the intake of other nutrients, particularly minerals and vitamins (Garcia *et al*., 2001).Micronutrients play very important roles in different metabolic processes and their excess or deficiency may disturb normal biochemical function of the body (Akhter *et al.*, 2002).

The main etiologic factor of various diseases, syndromes, and pathologic conditions is an excess, deficiency or imbalance of trace metal intake into the body (Zaichik, 2002). Zinc is an element found in virtually every cell of the human body and plays vital roles in the development and healthy growth of the human body. Zinc plays an important role in growth and has a recognized action on more than 300 enzymes by participating in their structure or in their catalytic and regulatory action. Zinc rich foods tend to be expensive, so Zn fortification is an important consideration, especially because daily intakes appear to be more useful physiologically than in intermittent doses (Salgueiro *et al.*, 2002). Zinc deficiency can result in poor growth, difficulty in wound healing, loss of appetite, undesirable skin changes, and adverse effects on the immune system (Akhter *et al.*, 2002). Zinc deficiency is also associated with sexual maturation, fertility, immunity, taste, and appetite (Torrejon *et al.*, 2004). The current reference daily intake (RDI) for Zn and Fe are 15mg/day and 18mg/day respectively (Acholonu, 2005). Overload of Zn (>100mg/d) also can be dangerous. It can depress the immune system, cause anemia, and copper deficiency, and decrease high density lipoprotein cholesterol in blood (Akhter *et al*., 2002).

Iron deficiency anemia (IDA) is a major cause of low birth weight and maternal mortality and has been re-recognized as an important cause of cognitive deficit in infants and young children (Darnton-Hill, 1999). IDA is

Table 3: Proximate composition of Bouillon cubes available in Nigeria (%)

	Mean value	Range
Moisture	2.68	2.25-2.92
Ash	57.90	48.15-63.20
Crude fat	5.68	5.50-5.90
Crude protein	12.95	10.50-17.50
Total Carbohydrate	20.79	17.43-26.20
Energy value (Kj/100g)	789.49	695.46-967.10

Adapted from Akpanyung 2005; N=6.

Table 4: Class and brand of food condiments used for the study

Bouillon cubes	Maggi crayfish;Maggi Tomato;Knorr cube
Chicken Seasoning	Benny Chicken Stock;First Chicken Seasoning;Onga Chicken Seasoning
Curry Powder	Ducros Curry ;Lion Curry ;Tiger Curry
Beef Seasoning	First Beef Seasoning;Victory Meat Spice
Mixed Spices	Aji-No-Moto;Integrated Mixed Spices; Indomie Seasoning;Onga Stew Seasoning; Onga Crayfish Seasoning
Thyme	Ducros Dried Thyme ;Lion Dried Thyme
Natural Spice	Uziza (Name in Ibo language of Nigeria)
Table Salt	Uncle Palm

one of the major public health problems in the world, especially in Asia and sub-Saharan African countries (Bassa *et al.*, 2003). However, both an inadequate supply of Fe to the body tissues and an excessive Fe accumulation within the body lead to significant morbidity (Lynch, 1997).

Monosodium glutamate (MSG) is widely used as a flavour enhancer in Asia and has been successfully fortified with ferric orthophosphate and ferrous sulfate encapsulated in zinc stearate (Hurrel, 1997). However Fe was not detected in a popular brand of MSG consumed in Nigeria. This confirms no national policy or intentional industrial effort at fortifying such food condiments in Nigeria. Pilot fortification trials with Fe-fortified fish sauce and curry powder both fortified with NaFeEDTA, resulted in significant improvement in the iron status in the population consuming the fortified products (Hurrel, 1997). The success of the fortified condiments presumably depends both on the absence of adverse color reactions in the finished products and on the addition of an absorption enhancer, such as EDTA.

Food fortification requires careful selection of both the food product to be fortified and micronutrient fortification compound to be added. Clearly, for micronutrients such as iron, the Fe compound must be first optimized with respect to relative bioavailability. However, if the food vehicle contains potent inhibitors of absorption, the added Fe like the native Fe will be poorly absorbed and will have little or no impact on the Fe status of the consumer. Thus the total micronutrient level of a food product does not necessarily indicate the level of absorbable or bioavailable micronutrient. The recommendations of the ECOWAS Nutrition Forum 2002 for essential nutrition action for national poverty reduction strategy includes iodization of common salt and possible use of sugar, flour, cooking oil and bouillon cubes as food vehicles for fortification against anemia and vitamin A deficiency, VAD (IFPRI, 2004). Similarly, the key strategy adopted to address micronutrient malnutrition at the 2nd International Workshop of Food-based Approaches for a Healthy Nutrition is the fortification of the above food items with vitamins and minerals (Rosanna, 2003).

Table 5: Lead,cadmium,iron and zinc levels in bouillon cubes and food condiments readily available in Nigeria

Sample group	Metal Concentration (µg/g)			
	Pb	Cd	Fe	Zn
Bouillon cubes	<0.02	3.63±0.03*	6.83 ±2.81	2.87±1.42
		(3.63)‡	(6.37)	(2.64)
		3.60 -3.65**	3.65 - 8.95	1.60 - 4.40
Chicken Seasoning	<0.02	4.58± 0.60	18.43 ±12.36	3.02± 0.68
		(4.56)	(16.10)	(2.97)
		3.90 -5.05	11.05 - 32.70	3.00 - 3.70
Curry powder	<0.02	1.03 ±0.93	202.25 ±150.94	21.22± 8.18
		(0.78)	(138.06)	(20.17)
		ND -1.80	32.35 - 320.85	13.65 - 29.90
Beef seasoning	<0.02	2.83± 2.79	52.95 ± 28.64	12.48 ± 12.41
		(2.02)	(48.92)	(8.87)
		0.85 - 4.80	32.70 - 73.20	3.70 - 21.25
Mixed spices	<0.02	3.04 ±1.76	29.34 ±19.52	8.90±7.94
		(2.53)	(17.17)	8.91(6.80)
		0.80 - 4.90	ND - 50.60	3.40 - 22.55
Thyme	<0.02	1.13± 0.04	255.70± 231.01	37.03± 15.66
		(1.12)	(196.72)	(35.33)
		1.10-1.15	92.35-419.05	25.95-48.10
Natural Spice (uziza)	<0.02	0.60	91.20	14.30
Table salt	<0.02	4.50	ND	1.00

* Mean ±SD **Range ‡Geometric mean ND =Non Detectable

The fortification of foods is often regarded as the most cost effective long term approach to reduce the prevalence of Fe deficiency. This can be in the form of "mass medication" by fortifying foods such as cereals, milk, salt and condiments that are widely consumed by both at risk populations and others who have little or no need for extra iron (Hurrel, 1997). Fortification with Fe is particularly difficult owing to the rapid oxidation of Fe. Estimates suggest that some 815 million households worldwide suffer from micronutrient deficiency. For many micronutrients, fortification during food processing is difficult. Biofortification of cereals is therefore an option with potential for application not only in developing countries, but also in the Western world (Poletti *et al.,* 2004). Our result confirms the observed efforts of the private sector in the fortification of bouillon cubes and curry powder which have high market penetration in West Africa (Hurrel, 1997; Darnton-Hill and Nalubola, 2002).The core issue may therefore become whether the marginally nourished person can afford, and will buy, the fortified food, and whether distribution channels can reach the poorest and neediest populations located in the more remote rural areas, rather than finding candidate foods for fortification (Darnton-Hill and Nalubola*,* 2002). The government can encourage food fortification by reducing the risk the companies have to bear by abolishing tariffs on imported fortificants, and by paying or loaning the initial fortification. The present tariff on importation of MSG stands at 30%, while that for importation of coloring agent, salts, and hydrolyzed vegetable protein (HVP) is 25% (RMRDC, 2003).

Our result indicates that the consumption of food prepared with these condiments do not represent any toxicological risk especially considering that these products are usually used in small quantities in food preparation. There is however the need for continuous surveillance of foods for heavy metal contamination, especially the local delicacies such as Ugba, Abacha and Nkwobi (names in Ibo language of Nigeria) which are prepared with relatively higher quantities of bouillon cubes and other local food additives. This result will compliment available baseline data on food composition in Nigeria and will be useful in estimating dietary intake of these metals in the general Nigerian population.

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