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Evaluation of Selected Heavy Metals in Palm Oil Sold in Some Markets in Yenagoa Metropolis, Bayelsa State, Nigeria

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Abstract

Plants have the potential to bioaccumulate heavy metals from the environment. When plant containing high content of heavy metal in their tissues/parts is ingested, it could have deleterious effect on the individual health. Palm oil is a major ingredient consumed directly as food and/or indirectly from other products they are used for by nearly all household in Nigeria. This study evaluated some selected heavy metals in palm oil sold in some major markets of Yenagoa metropolis, Bayelsa state, Nigeria. Triplicate samples were purchased from five markets (viz: Tombia junction, Akenfa, Swali, Igbogene and Opolo) in Yenagoa metropolis, Bayelsa state, Nigeria. The samples were prepared and analyzed used flame atomic absorption spectrophotometer. Result showed that the level of the various heavy metals ranged from < 0.001 - 0.246 ppm (copper), 0.451 - 1.610 ppm (zinc), 0.243 - 1.113 ppm (manganese), 15.084 - 33.994 ppm (iron), < 0.001 - 0.789 ppm (nickel) and < 0.001 - 0.064 ppm (cobalt), while chromium, cadmium and lead was below detectable limit. Analysis of variance showed that there was significant difference ($P < 0.05$) among the locations for each of the heavy metals apart from nickel. Based on the nutritional requirement of essential heavy metals in food, the level found in this study appears to be within tolerable level. Apart from few instances that some essential heavy metals (chromium, copper, cobalt and nickel) was not detected in the samples. Therefore, the need to supplement diets with other source of these essential metals during cooking.

Keywords: *Heavy Metals; Human Health Effect; Palm Oil; Yenagoa Metropolis*

Introduction

Palm oil is one of the two types of oil produced from the mesocarp of palm fruit. When the fruit is ripe, it's harvested and transported to palm oil mill for processing. Oil palm is processed into palm oil following different approaches based on scale of processors. According to Ohimain., *et al*. [1,2], Izah and Ohimain [3,4] over 80% of Nigeria oil palm industry is occupied by smallholder processors that uses rudimentary equipment for processing. While semi-mechanized and mechanized processors account for the 16% and 4% respectively [3,5,6]. The smallholder and semi-mechanized processors share about 50% of the processing method [3,5-7]. The smallholder processors process palm fruit into palm oil between 6 to 10 days [1,2,8-12]. Ohimain., *et al.* [1,2,8,10,11], Ohimain and Izah [6,12] also reported the period to complete each task in smallholder palm oil mill to include fermentation of sliced fruit (2 - 3 days), boiling/sterilization, digestion and pressing (1 - 2 days), fiber separation (1 day), palm press fiber fermentation (2 - 4 days). Furthermore, semi-mechanized processor uses 2 - 4 days to process palm oil from palm fruit [5,6,13]. Of these periods, fermentation of palm fruit alone takes 2 - 3 days [5,7].

Nigeria is the fifth largest palm oil producing country [14-18] accounting for about 55% of palm oil consumed in Nigeria while the rest 45% deficit are met through importation from major producing nation such as Indonesia and Malaysia [18]. Ohimain and Izah [19] reported that between 2000 and 2013, Nigeria oil palm industry did not grow massively compared to other major producing nations such as Indonesia, Malaysia and Thailand. Beside soup preparation, palm oil is used as an ingredient in making soap, margarine, soap candle, base for lipstick, waxes and polish bases, confectionaries, tin plating, lubricant, pharmaceutical products [3,4,20-24] and in the preparation of some traditional medicine.

According to Mahlia., *et al*. [25], Izah and Ohimain [3,4, 22], Ohimain and Izah [12], about 90% of global palm oil produced is utilized in food purposes including baking, confectionaries and soup and delicacies preparation. Palm oil is also consumed raw [22,26]. Palm oil is rich in carotene [27,28], energy and vitamins [29] such as vitamin A and E. lt also contain fatty acids, unsaponifiable constituents among others important characteristics. According to Okechalu., *et al*. [26], Izah and Ohimain [22], palm oil has antioxidant activities, cholesterol lowering, anti-cancer and protection against artherosclerosis tendencies.

Consequently palm oil is an essential constituent of diets to many families in Nigeria [29]. Regrettably, palm oil is subject to deterioration due to microbial infestation [4,22], thereby leading to alteration in some of the physiochemical parameters such as free fatty acid. This could have harmful effects to health [29].

The quality of palm oil sold in the markets in several region of Nigeria has been a source of concern for many years [29]. Beside possible adulteration, they could be contaminated by environmental contaminants (microorganisms and heavy metals). The processing environment by smallholders is carried in unhygienic condition [3,4,18]. Probably due to this, the quality of palm oil have been widely studied from the different part of the supply chain viz: mill, market, departmental stores etc at various locations in Nigeria. Some of these studies mainly focused on the physicochemical [2,26-28,30-37] and microbial properties [5,18,22,26,27,29,32,37].

Heavy metals are another type of environmental contaminants. They can be bioaccumulated by plant from contaminated environment. They could also be leached from the processing equipment over time depending on the metalloid used in the production at the processing facilities. Typically, authors have variously reported heavy metals as metalloids that have five times density compared to the density of water [38-41]. Some heavy metals are required in trace concentration and these groups of heavy metals are essential. Heavy metals induce toxicity on exposure above recommended level. The effect of toxicity due to common heavy metals that contaminate the environment and food resources have been documented by Izah and Srivastav [42], Izah., *et al*. [40,43], Muhammad., *et al*. [44], Palacios [45], Prashanth., *et al* [46].

Specifically studies have assessed the microbial and physicochemical quality of palm oil produced from palm oil mill [5] and sold in several markets in Yenagoa metropolis, Baylesa state [18]. But information about the heavy metals content is scares in literature. Hence, this study aimed at assessing the heavy metal quality of palm oil sold in some major markets in Yenagoa metropolis, Bayelsa state, Nigeria.

Materials and Methods

Study area

Yenagoa is the capital of Bayelsa state. The state lies in the sedimentary basin and fishing is a major occupation of the indigenous people [39]. Yenagoa is a fast developing city with few industries and several business activities. The region is prone to flooding and has high water table. Several types of wastes including municipal, market and sewage are discharged directly into the Epie creek (a major creek aligning the major road of the state capital) [39]. Most of the major market (Igbogene, Akenfa, Agudama-Epie, Tombia, Opolo, and Swali) in Yenagao metropolis is < 50 meters from a surface water resource.

Field Sampling

Triplicate samples of palm oil packaged in 75cl Ragolis bottle were purchased from five markets (viz: Tombia junction, Opolo, Swali, Akenfa and Igbogene) in Yenagoa metropolis, Bayelsa state, Nigeria. The samples were transported to the laboratory.

Sample preparation

2 ml of palm oil was preconcentrated on a hotplate before being dryashed at 450°C followed by dilution with distilled water. The ashed samples were allowed to cool in a dessicator. 5 ml of mixture of 1N nitric acid (HNO3) and 10 ml of 1N hydrochloric acid (HCl) was added to the ashed samples to form a solution. A reagent blank containing acid mixtures used was prepared.

Heavy metal determination

The heavy metal content of the prepared samples were determined using calibrated flame atomic absorption spectrometery (FAAS) (Model: GBC Avanta PM A6600) at varying wave length viz: 213.9 nm, 324.70 nm, 232.0 nm, 248.3 nm, 279.5 nm, 357.90 nm, 228.8 nm, 217.00 nm and 240.70 nm for zinc, copper, nickel, iron, manganese, chromium, cadmium, lead and cobalt respectively.

Statistical analysis

SPSS software was used to carry out the statistical analysis. The data were expressed as Mean ± error deviation. A one-way analysis of variance was carried out at P = 0.05, and Waller-Duncan multiple range test statistics was used for mean separation. Detectable heavy metals were correlated using Spearman rho correlation matrix.

Results and Discussion

The concentration of selected heavy metals in palm oil sold in Yenagoa metropolis, Bayelsa state, Nigeria is presented in table 1. While the Spearman rho correlation matrix is presented in table 2. Among the 9 heavy metals studied 3 viz: cadmium, copper and lead were not detected in the palm oil in all the locations. Typically, cadmium and lead are not essential metals; therefore their absence in the palm oil is an indication that the oil is free from toxicity associated with them. Furthermore, chromium is an essential metal need for the biosynthesis of glucose tolerance factor [40,46,47]. According to Prashanth., *et al*. [46], about 0.005 mg is the daily requirement of chromium by the human body per day. Therefore, absence of chromium in the body may predispose consumers of the palm oil in the study area to diseases caused by chromium deficiency. The diseases have been comprehensively documented by Prashanth., *et al* [46].

Copper, zinc, manganese, iron, nickel and cobalt were detected at varying concentration (Table 1). Copper concentration in the palm oil ranged from < 0.001 - 0.246 ppm, being significantly different (P < 0.05) among all the locations. Copper showed negative relationship with cobalt (r = -0.534; P < 0.05) (Table 2). Zinc concentration ranged from 0.451 - 1.610 ppm. There was no significant difference (P > 0.05) among the various locations apart from sample from Swali market. Zinc significantly correlate with iron (r = 0.596; P < 0.05) (Table 2). Manganese level ranged from 0.243 - 1.113 ppm. Basically, there was no significant difference (P > 0.05) among the various locations apart from sample from Igbogene market. The level of iron in the palm oil ranged from 15.084 - 33.994 ppm, being significantly different (P < 0.05) among the various locations apart from the samples from Akenfa, Swali and Igbogene which did not differ significantly (P > 0.05). Iron showed negative significant correlation with cobalt (r = -0.679; P < 0.01) (Table 2). Nickel concentration ranged from < 0.001 - 0.789 ppm, being not significantly different (P > 0.05) among the various locations. Beside the sample from Tombia (0.064 pp), cobalt was not present in the palm oil in the various locations. Furthermore, cobalt did not vary significantly (P > 0.05) among the various location apart from the sample from Tombia Junction market.

Locations	Cu, ppm	Zn, ppm	Mn, ppm	Fe, ppm	Ni, ppm	Co, ppm
Tombia	0.000 ± 0.000a	0.478 ± 0.624a	0.388 ± 0.112a	15.084 ± 1.781a	0.789 ± 0.338b	0.0640 ± 0.014b
Akenfa	0.072 ± 0.010b	0.584 ± 0.658a	0.580 ± 0.104a	33.994 ± 1.992c	0.348 ± 0.030ab	0.000 ± 0.000a
Swali	0.246 ± 0.015c	1.610 ± 0.202b	0.243 ± 0.070a	30.873 ± 3.131bc	0.397 ± 0.198ab	0.000 ± 0.000a
Igbogene	0.000 ± 0.000a	0.622 ± 0.045a	1.113 ± 0.120b	34.812 ± 2.541c	0.362 ± 0.057ab	0.000 ± 0.000a
Opolo	0.227 ± 0.016c	0.451 ± 0.029a	0.481 ± 0.104a	23.344 ± 2.111b	0.000 ± 0.000a	0.000 ± 0.000a

Table 1: *Heavy metals concentration in palm oil sold in Yenagoa metropolis, Nigeria.*

Data is expressed as mean ± standard error (n = 3); Different letters along the column indicate significant variation (P < 0.05) according to Waller-Duncan test statistics

Parameters	Cu	Zn	Mn	Fe	Ni	Co
Cu	1.000					
Zn	0.188	1.000				
Mn	-0.428	-0.193	1.000			
Fe	0.208	0.596*	0.393	1.000		
Ni	-0.472	0.247	0.280	0.240	1.000	
Co	-0.534*	-0.304	-0.209	-0.679**	0.389	1.000

Table 2: *Spearman's rho [r] of the heavy metals detected in palm oil sold in Yenagoa metropolis, Nigeria.*

**: Correlation is significant at the 0.05 level (2-tailed).*

***: Correlation is significant at the 0.01 level (2-tailed).*

N = 15; n = 3

The significant variation that exist among most location for each of the parameters could be associated to the fact that palm oil were bought from several locations i.e. nearby state predominantly in Rivers and Delta states. The palm oil may have picked up the heavy metals from the environment they were cultivated and/or from the processing equipment used by the processor depending on their makeup.

The lack of variation among some market of the same parameter could also be due to the fact that the retailers that sold the palm oil from the different market may have purchased from the same wholesaler. According to Ohimain and Izah [18], some of the palm oil dealers do sell in more than one market depending on the day the particular market transacts. Furthermore, Izah., *et al*. [48] have also reported that some fruit (such as watermelon paw-paw and pineapple) vendors sold their fruits in the various markets in Yenagoa metropolis depending on the transaction date.

Copper is an essential element that play essential role such as prevention of cell structure damage [49], maintenance of blood vessels, skin and epithelial cell [39,40,50], skeletal mineralization, cross-linking of collagen fibrils by copper containing enzyme (Lysyl oxidase), thereby enhancing the mechanical strength of the protein and forming strong and flexible connective tissue [45]. The absence of copper in 2 out of the 5 markets the palm oil palm was purchased from suggests potential copper deficiency in diets. However, the loss copper could be made up in other food resources such as vegetables that copper have been detected in the study area [39].

The concentration of iron in the palm oil appears moderate due to need for iron in diets. Iron play essential role in the body including biochemical/metabolic processes involved oxygen transport, deoxyribonucleic acid synthesis, electron transport chain and regulation of cell growth and differentiation [39,40,51-53], cofactor in enzymes (e.g prolyl and lysyl hydroxylases) involved in collagen bone matrix synthesis; (25-hydroxycholcalciferol hydroxylase) involved in the transformation of vitamin D to active form, which could affect calcium absorption [45,47]. Deficiency of iron could lead to several disorder as variously reported by Izah., *et al*. [40], Muhammad., *et al.* [44] while excess consumption of food high in iron could lead to conjunctivitis, choroiditis, and retinitis, and chronic inhalation could lead to benign pneumoconiosis [40,54].

Like iron, zinc is also an essential heavy metal that is required by the body. Prashanth., *et al*. [46] reported that 15 - 20 mg of zinc is required per day. Authors have variously reported the role of iron in the body to include wound healing, cell growth, development, differentiation, homeostasis, connective tissue growth and maintenance, DNA synthesis, RNA transcription, cell division, cell activation, and regulatory, catalytic, co-catalytic and structural roles in enzyme molecules [40,46,50,55], collagen synthesis, osteoblastic and alkaline phosphatase activities [46], taste acuity, prostaglandin production, bone mineralization, proper thyroid function, blood clotting, cognitive functions, fetal growth, and sperm production [55]. Prashanth., *et al*. [46] reported that the role of zinc in connective tissue is depended on metalloproteinase- an enzyme that is associated with reproductive, neurological, immune and dermatological systems. Furthermore, excess ingestion and deficiency could be detrimental to human health [40].

Manganese play essential role in the body just like other essential heavy metals, furthermore, 2 - 5 mg of manganese is required by the body daily. Some of the role include biosynthesis of mucopolysaccharides in bone matrix formation [45,47], activation of enzyme and as a component of metalloenzymes [40,46]. High and deficiency of manganese have been link to several disease conditions [40,54].

Cobalt is another essential heavy metal that is required by the body. According to Prashanth., *et al.* [46], an adult requires about 1.1g of cobalt daily. The authors' further reported that cobalt is a component of vitamin B12 which aid in the maintenance of human health, induces erythropoietin and blocks iodine uptake by the thyroid and it could also play a vital role in methionine metabolism. Cobalt was only present in one of the sample. Therefore, the palm oil in the study area is deficiency of cobalt thereby predisposing the consumers to cobalt deficiency diseases such as digestive and neuromuscular disorder and fatigue [46].

Nickel has been considered as a possibly essential trace mineral for several decades [43,56]. Deficiency and excess ingestion of food containing high nickel content could cause adverse health effect as reviewed and documented by Izah., *et al* [40].

Among all the detected heavy metals in this study, their concentration were in the order; iron > zinc > manganese > nickel > copper > cobalt. Iron account for about 93% of all heavy metal found in the palm oil in the study area (Figure 1). The trend reported in this study is comparable to the value previously reported in other food resources such as vegetables in the study area [39].

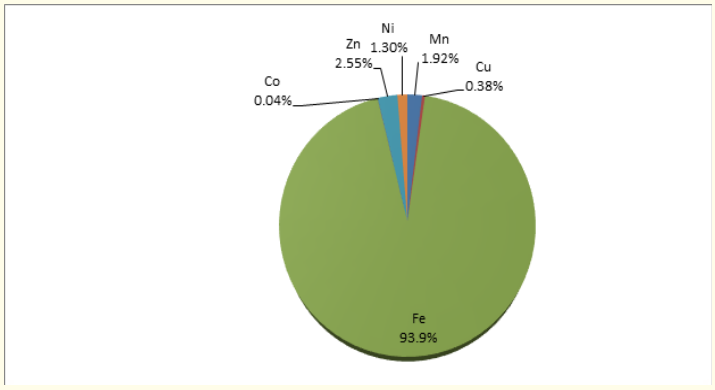

Figure 1: *Distribution of heavy metal concentration found in Palm oil sold in Yenagoa metropolis, Bayelsa state, Nigeria.*

Conclusion

This study evaluated the level of heavy metals found in palm oil sold in Yenagoa metropolis, Bayelsa state. The study found that heavy metals such as cadmium, lead and chromium were absence in the palm oil; while copper, nickel and cobalt was also not present in some of the samples from the various markets, while zinc, managnse and iron were present in all the sample. Based on the nutritional requirement of essential heavy metals, the concentration found in this study appears to be within acceptable level. Apart from few instances that some essential heavy metals (chromium, copper, cobalt and nickel) was not detected in the samples.

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