



<https://doi.org/10.36293/sfj.2021.0069>

HEAVY METAL CONTAMINANTS IN STORED COCOA BEANS

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Abstract

Cocoa (*Theobroma cacao*) is one of the leading agricultural commodity of foreign exchange earnings in Nigeria, with the country been one of the leading producers in the world. Cocoa bean is a product of many important economic and industrial values, also a raw material in many capacities. Environmental pollution from human activities which are sources of heavy metals in agricultural soils include, smelting, waste disposal, mining, exhausts, sewage sludge, urban effluent, agrochemical use as well as fertilizer applications. Safety of consumption of cocoa products and its use as raw materials premised the study to assay heavy metal contaminations, residues and to benchmark cocoa beans of local sources to the expected safety standard of the European markets. Cocoa producing communities in Osun state were surveyed, dry cocoa beans samples collected from six locations in two Local Government Areas of the State. Cocoa beans samples were prepared, digested and heavy metals; lead, chromium, cadmium, copper and manganese were assayed in the beans. Cadmium was not detected in all cocoa beans samples, lead detected in staggered presence (tolerable quantities) in the cocoa beans sourced from Ekosin and Ikirun. Chromium, copper and manganese were also present in varied quantities (tolerable) in analysed cocoa beans in selected growing communities in Osun state.

Keywords: Cocoa, Heavy metals, Contamination, Fertilizer, Pesticides

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INTRODUCTION

Theobroma cacao belongs to family Malvaceae, originating primarily from

tropical regions: Southeast Asia, Latin America, and West Africa and it is a small (4–8m tall) perennial tree crop. (Alex-Alan and Raul, 2007). The production of cocoa is an important sub-sector in the economy

of Nigeria, as a leading agricultural commodity of export value in the country. The produce cocoa, is a major raw material

in cocoa powder production, beverages, ice cream, yoghurt, confectioneries, syrup, jellies, chocolates and chocolates infused products like brownies (fudgy brownies), cakes, desserts and milk (Okpala, 2016).

Heavy metals are metallic elements that have a relatively high density, toxic and or poisonous even at low concentration (Lenntech, 2004). Heavy metals vary from copper, iron, chromium, lead, manganese, cadmium, arsenic, mercury, titanium, zirconium, niobium, molybdenum, palladium, rhodium, silver, cerium, astatine, polonium, lanthanum to bismuth. Environmental pollution and pollutants are of varied sources. Pollutions that results from human activities which are sources of heavy metals in agricultural soils include, smelting, waste disposal, mining, exhausts, sewage sludge, urban effluent, agrochemical and use of fertilizer (He *et al.*, 2005). Salman *et al.* (2006) reported that continual exposure of humans to heavy metals in lower measures is a co-factor of some neurological, carcinogenic and digestive diseases. In addition, after mycotoxins and microorganisms, heavy metals is third source of risk in human and animal food (Salman *et al.*, 2006).

Phosphorus fertilizer applications are sources of heavy metals in agricultural systems (Mortvedt and Beaton, 1995). Moore *et al.* (1998), stated repeated applications of inorganic manures and pesticides especially fungicides in soils resulted into high concentrations of extractable metals and subsequent increased their concentrations in the runoffs. Application of inorganic manures

and pesticides may result into heavy metal contamination of a typical cocoa (Aikpokpodion *et al.*, 2013). The fact that metal such as copper is a major component of most fungicides used on cocoa production globally, therefore the possibility of presence of some heavy metals residues in cocoa cannot be avoided (Aikpokpodion *et al.*, 2012). Lead contamination in cocoa products have become a concern, farming practices among other factors such as fertilizer applications, pesticides, composts and other soil additives conceivably give rise to lead contamination. Cocoa farming practises like use of lead – acid batteries to control termites and lead component as impurity in raw materials for copper – based fungicide production are potential sources of lead contamination in cocoa plantations (Aikpokpodion *et al.*, 2013).

MATERIALS AND METHODS

Dry cocoa beans were collected from farmers' store in six locations: Ekosin I and II, Okuku I and II, Odo-otin Local Government Area (LGA), Ikirun I and II, Ifelodun LGA of Osun State; they were properly labelled. A known quantity (10 g) of the labelled dry beans samples was separately milled into powder using an electric blender. The powders were separately digested according to USEPA, 3050B (1996). The level of contamination of cadmium, chromium, copper, manganese and lead were determined according to AOAC (2005). Lead, copper and manganese were assayed in the cocoa beans in the resulting solution following the protocol of Atomic Absorption Spectrophotometer (AAS) PG instrument 990FG (model), while cadmium and chromium were determined

spectrophotometrically using UV/V Spectrophotometer Model 752N.

RESULTS AND DISCUSSION

Table 1 and 2 showed the qualitative and quantitative presence of heavy metal in dry cocoa beans. Cadmium was totally absent in cocoa beans analyzed, chromium, copper and manganese were present in all communities (Table 1). Reports in this study indicated that cadmium was absent from all cocoa beans in the selected study locations analysed for heavy metal contaminants. Manganese, copper and chromium were present in varying concentrations. Lead was present only 2 of the 6 cocoa beans samples, and absent in the remaining 4 cocoa powder samples.

The absence of cadmium in the analysed cocoa beans samples in this study corroborates the earlier report of Aikpokpodion *et al.* (2013) on heavy metals presence in cocoa samples from Cross River State. Chromium, a mineral required by human in trace amount for optimal health was detected at 0.0036mg/kg to 0.06mg/kg. These values were less the maximum limit standard value of 1.0mg/kg accepted by the European Union (EU) for safe consumption of cocoa products. Lead was present in cocoa beans at Ekosin I and Ikirun I, but absent in beans samples at Ekosin II, Okuku I and II and Ikirun II (Table1).

Table 1: Qualitative Analysis of Heavy Metals in Cocoa Growing Communities of Osun State

Sample Source	Heavy Metals				
	Cadmium	Chromium	Copper	Manganese	Lead
Ekosin I	-	+	+	+	+
Ekosin II	-	+	+	+	-
Okuku I	-	+	+	+	-
Okuku II	-	+	+	+	-
Ikirun I	-	+	+	+	+
Ikirun II	-	+	+	+	-

Keys: (+) = Present; (-) = Absent.

Table 2 showed the concentration of chromium in cocoa beans was 0.036mg/kg (Ekosin I and II), 0.012mg/kg (Okuku I and II, Ikirun I) and 0.06 mg/kg (Ikirun II). No significant difference ($P \leq 0.05$) was recorded in quantity of chromium in cocoa beans at Ekosin I and II, as well as concentration of same metal at Okuku I and II, Ikirun I. The concentration of chromium was significantly higher in cocoa beans at Ikirun II than other location sample locations. The concentration of

copper was 0.161 mg/kg (Ekosin I), 0.18mg/kg (Ekosin II), 0.171mg/kg (Okuku I and II), 0.21mg/kg (Ikirun I) and 0.015mg/kg (Ikirun II). Significant similarities were recorded in copper concentrations in cocoa beans at Ekosin II, Okuku I and II. Significant differences ($P \leq 0.05$) existed in concentrations of copper in cocoa beans at Ekosin I, Ikirun I and II. Lowor and Shiloh (2013) reported that the occurrence of copper in the environment is natural but its use as bases for most

fungicides and fertilizer increased its levels in agriculture.

Analysis of dry cocoa beans in this study showed copper contamination ranging was 0.015mg/kg to 0.21mg/kg, none of which was up to the E.U. maximum residue limit (50 mg/kg). Koka *et al.* (2011) in their study of GC-MS analysis of cocoa beans reported copper contamination range was 0.08mg/kg to 0.22 mg/kg. Aikpokpodion *et al.* (2013) in study of heavy metal contamination in cocoa beans from Ogun, Ondo and Cross River States reported a copper residual level of Ogun Statecocoa to be 25 mg/kg, 26.1mg/kg in Ondo State cocoa and 18 mg/kg in Cross River State cocoa. Amankwah (2013) also reported a higher concentration of 52.35mg/kg copper contamination in cocoa from Kwaku Praso in Ghana. These values are higher than what were reported in this study. This may be as a result of low level usage of copper – based fungicides by farmers in the selected communities from which the cocoa beans analysed were collected.

Manganese was the most abundant heavy metal contaminant in this study, ranging from 0.32-0.445mg/kg. Ikirun II has the highest concentration of manganese (0.445mg/kg), while Okuku I had lowest (0.32 mg/kg). The concentration of manganese contamination in cocoa bean from study location was lower compared

to values reported in previous studies. Nartey *et al.* (2012) reported 33.60mg/kg of manganese as contaminant in cocoa beans from Wassa Akropong, Ghana, a value higher than observation in this study. Lead concentrations in cocoa beans at Ekosin I was significantly higher (0.173 mg/kg) than other locations, and 0.019mg/kg at Ikirun I. Significant difference ($P \leq 0.05$) was also recorded in lead concentrations in cocoa beans sourced at Ekosin I and Ikirun I (Table 2). Lead concentration showed staggered presence in this study, with cocoa beans from Ekosin II, Okuku I and II, Ikirun II had no lead contaminant, while it was present in the beans at Ekosin I (0.173mg/kg) and Ikirun I (0.019mg/kg). Aikpokpodion *et al.* (2013) reported a lead concentration ranging from 0.85 to 3.0mg/kg in cocoa beans, values which was higher compared to findings in this study. Nartey *et al.* (2012) also reported a lead concentration range of 0.05 to 0.07mg/kg in cocoa beans from Wassa Akropong, Ghana, values which was also lower to the observations in this study. The concentration of lead in cocoa beans analysed in this study was under the accepted maximum residual limit of 1.0mg/kg by the European Union.

Table 2: Quantitative Analysis of Heavy Metals in Cocoa Growing Communities of Osun State

Collection Centres	Heavy Metal (mg/kg)*				
	Cadmium	Chromium	Copper	Manganese	Lead
Ekosin I	0.00 ^a ±0.0**	***0.036 ^b ±0.001	0.161 ^c ±0.001	0.356 ^b ±0.001	0.173 ^a ±0.001
Ekosin II	0.00 ^a ±0.0	0.036 ^b ±0.001	0.18 ^b ±0.01	0.363 ^b ±0.001	0.00 ^c ±0.0
Okuku I	0.00 ^a ±0.0	0.012 ^c ±0.001	0.171 ^b ±0.001	0.32 ^d ±0.01	0.00 ^c ±0.0
Okuku II	0.00 ^a ±0.0	0.012 ^c ±0.001	0.171 ^b ±0.001	0.356 ^b ±0.001	0.00 ^c ±0.0
Ikirun I	0.00 ^a ±0.0	0.012 ^c ±0.001	0.21 ^a ±0.01	0.338 ^c ±0.001	0.019 ^b ±0.001

Ikirun II	0.00 ^a ±0.0	0.06 ^a ±0.01	0.015 ^d ±0.001	0.445 ^a ±0.001	0.00 ^c ±0.0
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Keys: *milligram per kilogram; **Standard Error of Mean (SEM); ***Means followed by same letter in each column are not statistically different ($P \leq 0.05$).

Figure 1 showed distribution of heavy metal contaminants in the cocoa beans samples in selected producing communities. Manganese was present in concentrations much higher in the cocoa beans samples from the selected growing communities in this study, compared with other heavy metals contaminants detected in all the analysed beans samples. Concentrations of manganese varied from

0.32 mg/kg at Okuku I to 0.44 5mg/kg at Ikirun II (Figure 1). Copper and chromium were also present in all the cocoa beans analysed but in lower concentrations compared to manganese. However, the concentration of copper in the cocoa beans sample was higher than chromium, except in the cocoa beans at Ikirun II with 0.06 mg/kg chromium (Figure1).

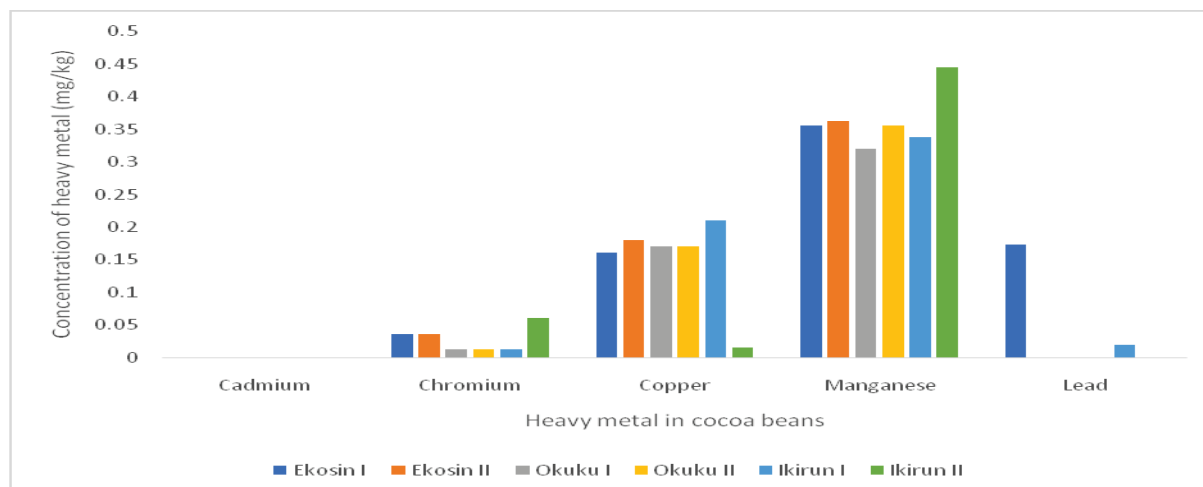


Figure 1: Distribution of Heavy Metals in Cocoa Growing Communities of Osun State

CONCLUSION

Concentrations of the five heavy metals analysed in cocoa beans in selected study locations of cocoa growing communities in Osun State were less maximum residue limits standard of European Union, therefore dry cocoa beans in study areas are considered safe of metal contamination and poses little or no risk to human consumption of the cocoa products.

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