



# Public Health Implications of Some Heavy Metals Contained in Palm Wines of Wilberforce Island Area, Nigeria

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## Abstract

This study evaluated the heavy metals hazard of palm wine from *Raphia* species sold in Wilberforce Island, Bayelsa State Nigeria. Triplicate samples were obtained from six locations in Wilberforce Island and analyzed using atomic absorption spectrophotometer. The health risk associated with heavy metal contaminants was calculated following standard protocol. Results of heavy metals in palm wine were in the range of 0.157–0.319mg/L, 0.554–0.983mg/L, 0.000– 0.2289mg/L, and 0.123–0.5299mg/L for zinc, iron, cobalt, and copper respectively. There were significant discrepancies ( $p < 0.05$ ) in the palm wine samples across various locations for the different parameters. Metals such as cadmium, chromium, nickel, and lead were not detected in palm wine, indicating that toxicity related to them is non-existent. However, zinc, cobalt, and copper were observed at low concentrations, while iron levels exceeded regulatory comparison. This is possibly an indication of iron-rich soils which are prevalent in the area. It may also have resulted from activities releasing this metal within the study area. Average daily intake and hazard quotient and health index ( $< 1$ ) indicate no adverse acute health effect. To forestall potential health risks associated with heavy metals in palm wine, there is a need to regularly evaluate heavy metal concentrations.

**Keywords:** Contaminants; Heavy metals; Public health; Palm wine.

## 1. Introduction

Palm wine is consumed in different parts of the world, especially in Asia, Africa and South America [1]. Palm wine has some social significance in the culture of several ethnic groups in Nigeria. For instance, it is commonly consumed during ceremonies (including burial or funeral, marriage, naming or birth celebrations, coronation of kings, community meetings, chieftaincy-title conferment), relaxation by youths and elderly [1]. Palm wine is sometimes infused with some medicinal plants for the treatment of specific diseases in traditional settings in Nigeria [2].

Palm wine contains sugar (mostly glucose and sucrose, and other reducing sugar such as fructose, maltose and raffinose), about 9.5% of sucrose [3] and 12 – 15% by weight of sucrose [2]. Basically, as fermentation period of palm wine increases, the total soluble solids and acidity is spiked, while moisture, reducing sugar and pH decreases as fermentation period increases [4].

Heavy metals are among the most reported environmental contaminants occurring in water [5], air [6], soil and sediment. Plants have the tendency to take up heavy metals from soil. In addition, some heavy metals are required by plants at certain concentrations for optimum growth, while some others such as lead, arsenic, cadmium and mercury have no known biological function. As such, their presence in edible materials portends adverse toxicity to humans if consumed. The toxicity and diseases associated with exposure to these heavy metals have been reported in literatures [7].

Although previous research used to concentrate on comparing the levels of heavy metal toxicants in food with regulatory standards, this approach has not been quite specific with identifying health risks associated with the presence of different metallic ions. Based on the foregoing, health risk assessment have been used to decipher the potential health effects associated with heavy metals found in food and drinks ingested by humans, or inhaled. The health indices commonly used to assess health risks includes average daily intake, hazard index, and target quotient

for non-carcinogenic risk [8-10]. In addition, the carcinogenic risk of selected heavy metals is often assessed for some heavy metals such as cadmium, nickel, chromium, lead and arsenic.

The assessment of heavy metal constituents of palm wine could provide useful information about the carcinogenic and non-carcinogenic health effects associated with its consumption. Therefore, this study is aimed at assessing the public health implications of heavy metals contaminants of palm wine in Wilberforce Island, Nigeria.

## 2. Materials and Method

### 2.1. Study Area

Wilberforce Island cuts across several communities in different local government areas of Bayelsa State such as Yenagoa, Kolokuma-Opokuma, Sagbama and Southern Ijaw local government areas [11]. The island is formed from a tributary of river Niger (coursing through Nun River). The area is a typical rain forest interspersed by freshwater swamps [12]. Ohimain, *et al.* [12] reported that the topography of the Island is flat with depressions and most of the terrestrial habitats get submerged on yearly basis due to water flooding.

### 2.2. Sample Collection

Samples of *Raphia* palm wine were collected from different palm wine vendors across six locations in Wilberforce Island, Bayelsa state, Nigeria. At each location, triplicate samples were purchased in different pre-sterilized sample containers. Each sample was acidified with drops of nitric acid. Thereafter, test materials were stored in ice chest and transported to the laboratory.

### 2.3. Heavy Metal Analysis

Exactly 25 mL of palm wine liquor was transferred into 100 mL glass beaker. The sample was pretreated with 5 mL of concentrated nitric acid (HNO<sub>3</sub>). Samples were prepared following the method previously described by Aigberua, *et al.* [13]. The resultant diluents and a reagent blank were aspirated into the GBC Avanta PM A6600 flame atomic absorption spectrophotometer for heavy metal analysis at varying wavelengths [13]. Metal concentrations were expressed as mg/L units.

### 2.4. Quality Control

Distilled water was used to perform instrument zeroing (blank), while reagent blank determination was applied to negate any interferences stemming from chemicals used. In addition, all parametric analyses were carried out in triplicate so as to ensure the repeatability of data obtained. Quality check concentrations were inserted between sample runs to check and correct instrument deviations.

### 2.5. Health Risk Index

Health risk index was used to evaluate the level of concern associated with consumption of palm wine from the study area. The human health risk was established using average dietary intakes (ADI), hazard quotient (HQ) and hazard index (HI).

### 2.6. Average dietary intake:

The average daily intakes (ADI) of detected heavy metals including zinc, iron, copper and cobalt from the consumption of palm wine was calculated using formula presented by United States Environmental Protection Agency, and applied by Taiwo, *et al.* [14].

$$\text{Average Daily Intake (ADI)} = \frac{\text{EF} \times \text{DC} \times \text{Mc} \times \text{IR}}{\text{Wb} \times \text{AT}}$$

The resultant values used for ingestion rate of palm wine (IR) is 0.03 L/day [14], concentration of individual metals (Mc), exposure duration (DC) which is 48.9 years based on Nigeria's life expectancy rate [15], exposure frequency (EF) which is 250 days/year, average time (AT) [14] and body weight (Wb) for Adult (70 kg) and undergraduate (16 - 25 years) is 65 kg [16].

### 2.7. Hazard quotient (HQ)

Hazard quotient is the ratio of average daily intake and reference dose (RfD). It is used to express the risk of non-carcinogenic effects [14]. When the value is < 1 it indicates no obvious adverse risk/effect, and when its > 1 it denotes non-carcinogenic adverse health risks [14].

$$\text{Hazard quotient (HQ)} = \frac{\text{ADI}}{\text{RfD}}$$

The reference dose (RfD) of detected heavy metals in palm wine viz: Cu (0.04 mg/kg/day), Zn (0.3 mg/kg/day), Fe (0.7 mg/kg/day) and Co (0.0004 mg/kg/day) [17], while ADI is the average daily intake.

### 2.8. Hazard Index

The hazard index (HI) associated with consumption of palm wine from the study area was determined. The hazard index is the sum of hazard quotients of detected heavy metals (zinc, copper, iron and cobalt) [14].

$$\text{Hazard Index (HI)} = \sum HQ_{fe} + HQ_{zn} + HQ_{co} + HQ_{cu}$$

## 2.9. Statistical Analysis

Statistical package for Social Sciences (SPSS) software was used to carry out data analysis. The mean value of triplicate data of parameters was expressed as mean  $\pm$  standard deviation. One way analysis of variance was carried out to show significant variation at  $p = 0.05$ . Also Tukey HSD pair-wise test statistics was used to discern the source of observed variation. Mean concentration of heavy metals was used to calculate the risk associated with consumption of palm wine within the study area.

## 3. Results

Table 1 presents the concentration of heavy metals in palm wine in Wilberforce Island, Bayelsa state, Nigeria. The concentrations of zinc, iron, cobalt, and copper ranged from 0.157 – 0.319 mg/L, 0.554 – 0.9839 mg/L, 0.000 – 0.2289 mg/L and 0.123 – 0.5299 mg/L respectively. There were significant variations ( $p < 0.05$ ) among different locations for the detected heavy metals, while cadmium, nickel, chromium and lead were below detection limit, an indication of their non-toxic tendencies.

**Table-1.** Level of selected heavy metals in palm wine sold in Wilberforce Island, Bayelsa state, Nigeria

Locations	Zinc, mg/L	Iron, mg/L	Cobalt, mg/L	Copper, mg/L	Nickel, mg/L	Chromium, mg/L	Cadmium, Mg/L	Lead, mg/L
A	0.605 $\pm$ 0.004e	0.765 $\pm$ 0.024c	0.000 $\pm$ 0.000a	0.213 $\pm$ 0.008c	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
B	0.319 $\pm$ 0.010d	0.777 $\pm$ 0.016c	0.000 $\pm$ 0.000a	0.443 $\pm$ 0.008e	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
C	0.171 $\pm$ 0.022a	0.646 $\pm$ 0.040b	0.193 $\pm$ 0.006d	0.529 $\pm$ 0.020f	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
D	0.157 $\pm$ 0.009a	0.888 $\pm$ 0.029d	0.172 $\pm$ 0.009c	0.166 $\pm$ 0.014b	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
E	0.205 $\pm$ 0.006b	0.983 $\pm$ 0.011e	0.111 $\pm$ 0.008b	0.251 $\pm$ 0.004d	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
F	0.228 $\pm$ 0.001c	0.554 $\pm$ 0.024a	0.228 $\pm$ 0.002e	0.123 $\pm$ 0.006a	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00

Data is expressed as mean  $\pm$  standard deviation; different letters along the columns indicate significant variations according to Tukey HSD statistics

The average daily intake of detected heavy metals in palm wine sold in Wilberforce Island, Nigeria is shown in Table 2. In locations A and B, cobalt was not detected. As such, the average daily intake is zero. Apart from this situation, the average daily intake was highest with a concentration of 1.00E-04 mg/day/L for zinc and cobalt constituents of palm wine from location F, particularly among individuals with body weight of 70 kg, while being the lowest with a concentration of 9.830E-05 mg/day/L for copper constituents of palm wine from location A, particularly among individuals with body weight of 65 kg.

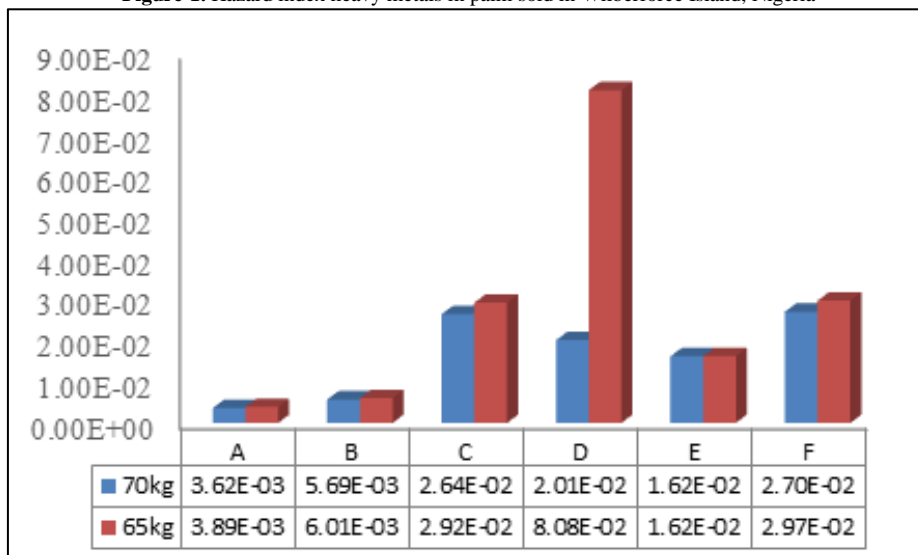
The hazard quotient of detected heavy metals in palm wine sold in Wilberforce Island, Nigeria is shown in Table 2. Based on body weight considerations, the hazard quotient for each test metal across various locations was less than 1 ( $< 1$ ) for palm wine sold in Wilberforce Island, Nigeria. Also the hazard index was  $< 1$  in both age grades under consideration (Figure 1).

**Table-2.** Average daily intake of detected heavy metals in palm wine sold in Wilberforce Island, Nigeria

Locations	Zn		Fe		Co		Cu	
	70 kg	65 kg	70 kg	65 kg	70 kg	65 kg	70 kg	65 kg
A	2.60E-04	2.80E-04	3.30E-04	3.50E-04	0.00E-00	0.00E-00	9.13E-05	9.83E-05
B	1.40E-04	1.50E-04	3.30E-04	3.60E-04	0.00E-00	0.00E-00	1.90E-04	2.00E-04
C	7.00E-05	8.00E-05	2.80E-04	3.00E-04	8.00E-05	9.00E-05	2.30E-04	2.40E-04
D	7.00E-05	7.00E-05	3.80E-04	4.10E-04	7.00E-05	8.00E-05	7.13E-05	7.68E-05
E	9.00E-05	9.00E-05	4.20E-04	4.50E-04	5.00E-05	5.00E-05	1.10E-04	1.10E-04
F	1.00E-04	1.10E-04	2.40E-04	2.60E-04	1.00E-04	1.10E-04	5.28E-05	5.69E-05

**Table-3.** Hazard quotient of the detected heavy metals in palm sold in Wilberforce Island, Nigeria

Locations	Zn		Fe		Co		Cu	
	70 kg	65 kg	70 kg	65 kg	70 kg	65 kg	70 kg	65 kg
A	8.67E-04	9.33E-04	4.71E-04	5.00E-04	0.00E+00	0.00E+00	2.28E-03	2.46E-03
B	4.67E-04	5.00E-04	4.71E-04	5.14E-04	0.00E+00	0.00E+00	4.75E-03	5.00E-03
C	2.33E-04	2.67E-04	4.00E-04	4.29E-04	2.00E-02	2.25E-02	5.75E-03	6.00E-03
D	2.33E-04	2.33E-04	5.43E-04	5.86E-02	1.75E-02	2.00E-02	1.78E-03	1.92E-03
E	3.00E-04	3.00E-04	6.00E-04	6.43E-04	1.25E-02	1.25E-02	2.75E-03	2.75E-03
F	3.33E-04	3.67E-04	3.43E-04	3.71E-04	2.50E-02	2.75E-02	1.32E-03	1.42E-03

**Figure-1.** Hazard index heavy metals in palm sold in Wilberforce Island, Nigeria

## 4. Discussion

The concentrations of zinc and copper in palm wine were lower than WHO permissible limits of 3.000 mg/L and 2.000 mg/L respectively for drinking water. On the other hand, iron concentrations across all locations were higher than the WHO permissible limit of 0.300 mg/L. In addition, cobalt has no specified permissible limit. These detected heavy metals are known to have biological functions in humans [7], while their functions in living organisms have been comprehensively discussed in literatures [7, 18, 19]. However, minute concentrations of zinc and copper in palm wine suggest that there may be no acute heavy metal toxicity associated with its consumption. It is important to note that an extremely high concentration of cobalt could lead to thyroid gland dysfunction. Also, when iron concentration is excessive, it could lead to siderosis [20].

The heavy metals concentration recorded in this study has some dissimilarity with values reported in some Nigerian States such as Ogun [14], Enugu [21], Delta, Bayelsa [22] and Abia states [23]. Observed variations may have emanated from differences in the biochemical composition of palm wine which are tapped from divergent sources. In the same vein, differences may have emanated from a shift in the minerals and heavy metal constituents of planting soils, as well as other heavy metals emission sources within the area of palm cultivation, followed by the quality of packaging materials used for the storage of palm juice.

There is no adverse effect accompanying the consumption of palm wine drink from study area. This is based on the hazard index, which is the total effect of ingestible heavy metals that can be bio-accumulated from ingesting palm wine. As such, the hazard index is less than 1 ( $< 1$ ), thereby, indicating the absence of chronic risk whilst non-cancer risk remains a function of consumers' other health conditions [10, 24]. In this study, the major carcinogenic risk indicator metals such as cadmium, lead, nickel and chromium were not detected, hence the tendency of developing cancer due to the consumption of palm wine from this study area is rare. The findings from this work are comparable to observations of Taiwo, *et al.* [14] where hazard quotients and hazard index were reported at less than 1 ( $< 1$ ) for palm wine purchased in Abeokuta, Ogun state, Nigeria.

## 5. Conclusion

Wine obtained from *Raphia* and *Elaeis* palms are usually consumed in Nigeria both ceremonially and leisurely. Often times, food and drinks can be contaminated with heavy metals during storage and handling processes. By so doing, the ingestion of toxic metals at levels exceeding permissible threshold may portend adverse health effects or aggravate underlying health conditions over time, particularly depending on a person's health status and/or consumption rate. Hence, the quality assessment of palm wine is essential in evaluating potential health concerns that are associated with consumption. This study assessed the heavy metals hazard of palm wine consumed in Wilberforce Island, Bayelsa State, Nigeria. The results showed that some heavy metals which are major carcinogenic risk indicators such as chromium, nickel, cadmium and lead were not detected in palm wine. Other metals such as copper and zinc, although present, were observed at concentrations within permissible regulatory limits. Conversely, the recorded iron concentrations exceeded allowable limits, this possibly resulting from the elevated levels of iron in cultivation soils. Again, the raised iron concentrations may have emanated from anthropogenic activities infiltrating cultivated farmlands. Overall, the average daily intake, hazard quotients and hazard index depicts no adverse health effect from consumption of palm wine in the study area.

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