# EVALUATION OF SOME HEAVY METALS IN SELECTED CANNED SARDINE SOLD IN YENAGOA METROPOLIS, BAYELSA STATE, SOUTHERN NIGERIA

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**ABSTRACT**

The content and risk of nine heavy metals (Cd, Ni, Cu, Pb, Mn, Cr, Co, Fe and Zn) were quantified and assessed in canned sardines consumed in Nigeria. The amount of heavy metals in the sardines were assessed with the aid of atomic absorption spectrometry (AAS) after digesting canned sardine samples with mixture of $HNO_3$ and HCl. The quantified content (mg/kg) of the heavy metals ranged from 0.09 – 0.38 for Cd, 0.12– 0.48 for Pb, 0.01 – 1.5 for Cr, 0.06 -1.6 and 0.06 – 1.68 for Mn. The Estimated Dietary Intake **(**EDI) of Cd varied between 0.12 and 0.53µg/kg bw/day and 0.02 to 0.12µg/kg bw/day for the children and adults respectively. Similarly, the EDI for Pb varied between 0.17 and 0.67 µg/kg bw/day and 0.04 to 0.17 µg/kg bw/day for children and adults respectively. For Cr, EDI values obtained ranged between 0.01 – 2.08µg/kg bw/day for children and 0.04 – 0.52µg/kg bw/day for adults. The Target Hazard Quotients**(**THQs) values of heavy metals for child exposure in canned sardines ranged from 1.20 to 9.31 for Cd, 1.10 to 8.64 for Pb, 1.29 to 9.31 for Cr, 1.40 to 7.51 for Ni, 1.43 to 9.64 for Cu, 1.04 to 5.70 for Mn, 1.29 to 8.86 for Zn, 1.33 to 5.70 for Fe. The EDI values indicated that the intakes of metals from the consumption of the canned sardines were within their provisional tolerable daily intake limits. However, too much consumption of these products could lead to exposure to high amounts of metals.

**Keywords**: Heavy metals, Canned Sardines, Daily intake, Fish

## INTRODUCTION

The abundance of minerals, proteins and essential fatty acids, such as omega-3 class of fatty acids, in fish makes it a highly recommended food source (Usydus *et al*., 2008; Akinwumi, 2011; Hosseini-Moghaddam *et al.*, 2013). The essential fatty acids in fish are proficient in the prevention of thrombosis and coronary heart diseases (Usydus *et al*., 2009; Sirot *et al.* 2010; Sobhanardakani *et al.*, 2017).

Going by the fact that fish accounts for about 40% of total protein consumed by Nigerians, the demand for fish in Nigeria is way beyond the capacity of local fish production and hence the country demands

heavily on imported fish and by-products of fish, which usually comes in cans (Tokula, 2009; Federal Department of Fisheries, 2008). The benefits of canned fish include extended shelf life, survival outside refrigeration, reduction of time in preparation of food and ease of transport (Kapica and Weiss, 2012). However, the utilization of chemical preservatives such as potassium/sodium nitrate in their production and the presence of chemical contaminants from the environment and incorrect packaging/technological processing are major disadvantages of canned fish (Buculei *et al*., 2014; Amit *et al*., 2017). It is almost impossible to completely prevent pollution of canned fish by chemical contaminants from the environment, and as such canned food can be contaminated in the process of canning (We˛glarzy, 2007; Ociepa-Kubicka and Ociepa, 2012).

Besides, naturally, fish have the capability to bio-accumulate heavy metallic elements, from contaminated water, via absorption in the gill surface. Increase in anthropogenic activities have resulted in profound contamination of water bodies by heavy metals, which poses a great threat to health of humans (Poty *et al*., 2012). Heavy metallic elements like cadmium, lead, mercury, arsenic, nickel, aluminium and chromium have been shown to instigate deleterious effects in humans (Orororo *et al*., 2018; Ekakitie *et al*., 2021; Udi *et al*., 2022; Orororo *et al*., 2022). To ensure safety in the use of canned fish, several studies have evaluated the rate in which canned fish are contaminated by heavy metals all around the world, such as Austria (Suppin *et al*. 2005); Saudi Arabia (Ashraf *et al*. 2006); USA (Shiber 2011); Turkey (Mol 2011); Mexico (Ruelas-Inzunza *et al*. 2011); Brazil (Medeiros *et al*. 2012); Spain (Olmedo *et al*. 2013); China (Qin *et al*. 2015); Iraq (Jasim and Shkhaier, 2016); Iran (Sobhanardakani *et al*., 2017).

Studies examining the gravity of heavy metal pollution of canned fish available in Nigeria have also been carried out such as in Port Harcourt (Iwuoha *et al*., 2013),

Benin city (Odiko *et al*., 2017); Lagos (Babalola *et al*., 2014) and Calabar (Ikpeme *et al*., 2009), with varying results. While some reported alarming contents of heavy metals in samples evaluated, others noted that the heavy metallic elements detected were within internally acceptable limits with no health consequence after human consumption. For example, Ikpeme *et al*. (2009) evaluated heavy metals present in canned fish and meat purchased in Calabar and found an alarming level of lead in them. Given the need for adequate data in the assessment of heavy metal pollution of canned fish and their consequential risks on human health and the fact that studies evaluating heavy metals in canned fish available in Nigerian markets, are limited, this study was designed to evaluate some heavy metals in canned sardine sold in markets in Bayelsa State, South South, Nigeria.

## MATERIALS AND METHODS

**Sample collection:**

Ten (10) brands of sardine (designated as CS1 to CS10) were purchased from Supermarkets in Yenagoa metropolis, Bayelsa State, Nigeria. The samples had varied batch number and production dates in order to examine the heavy metals variations.

**Chemicals and Reagents:**

Analytical grade chemicals and regents were employed in this analysis. The working standards of Fe, Cd, Ni, Pb, Cr, Co, Cu, Zn and Mn (produced by Merck, Darmstadt, Germany) were prepared by diluting concentrated stock solutions of 1,000 mg/L with 0.25 mol/L nitric acid. Hydrogen peroxide (30 % w/v), HCl (36 % v/v) and Nitric acid (69 % v/v Analar) were obtained from British Drug House, Poole, United Kingdom.

**Sample digestion and chemical analysis:**

Two gram of sardine samples was measured into a 100 mL digestion tube and 25 mL of a mixture of $HNO_3$, HCl and $H_2O_2$ in a ratio of 1:3:1 was added. The

digestion tube was covered and heated at 100 °C for 1 h with the use of a temperature controlled hot plate till a clear and colourless solution was seen. The digest was cooled, filtered and made to 50 mL with 0.25 mol/L $HNO_3$. The amounts of heavy metals in the digest were assessed usingflame atomic absorption spectrometry (Perkin Elmer, Analyst 200).

**Quality assurance:**

The quality assurance procedures employed involved the use of high purity reagents, method blanks and spike recovery technique. The method blanks were undertaken for all heavy metals by going through the steps in the approved protocol without the sample. The blanks were shown to contain no heavy metals. The spike recovery was done by adding known amount of a chosen heavy metal into a fresh aliquot of the samples and repeating the steps in the prescribed procedure. The percent spike recoveries of the various heavy metals were 90.2%, 95.9%, 101.4%, 92.6%, 99.3%, 90.8%, 94.7%, 97.2% and 93.0% for Cd, Pb, Ni, Cr, Cu, Co, Mn, Fe and Zn respectively.

**Evaluation of estimated dietary intake (EDI) and target hazard quotients (THQ):**The EDI of heavy metals from the eating of the sardines was assessed by using the expression (Iwegbue, 2015; Iwegbue *et al*., 2015):

$$EDI\ (\mu g/kg\ bw/day) = \frac{Ingestion\ Rate \times Concentration\ of\ metals\ in\ canned\ fish}{Body\ Weight} \quad (1)$$

The ingestion rate of 20.8 g was used based on the per capita consumption of 7.6 kg of fish in Nigeria (Iwegbue *et al*., 2015; Tesi and Iniaghe, 2020; Afolabi *et al*., 2022).60 kg and 15kg were taken as standard body weight for adults and children respectively.

The target hazard quotient (THQ) was used to evaluate the extent of concern resulting from intake of heavy metals via the eating of these canned fish. THQ

values were computed using the expression by the United States Environmental Protection Agency (1989):

$$THQ = \frac{EF \times ED \times EDI}{RFD \times AT} \times 10^{-3} \quad (2)$$

Where EF = exposure frequency (365 days/year), ED = exposure duration (30 and 6years for adults and children respectively), AT = averaging time for non-carcinogens (ED × 365 days). The AT for children was 2190 days while the AT for adults was 10950 days. RFD = the oral reference dose. The RFDs (in mg/kg/day) used were Ni ($2 \times 10^{-2}$), Cr ($3\times 10^{-3}$), Cu ($4.0 \times 10^{-2}$), Pb ($4 \times 10^{-3}$), Mn ($1.4 \times 10^{-1}$), Zn ($3.0 \times 10^{-1}$), Fe ($7.0 \times 10^{-1}$) (USDOE, 2011). A THQ value < 1 it indicates that there is no health concern and vice versa (Iwegbue, 2015). Due to the potential synergistic impacts of heavy metals, the THQ values of the individual heavy metals were added together to obtain the total THQ (ΣTHQ) which also has the same interpretation as THQ.

**RESULTS**

The results of the quantity of heavy metals in the canned sardines are displayed in Table 1 while the computed EDI and THQs values of heavy metals upon consumption of the canned sardines are shown in Tables 2 and 3 respectively.

**Table 1: Quantity of Heavy metals (mg/kg) in canned sardines**

| | Cd | Pb | Cr | Ni | Cu | Mn | Zn | Fe |
|---|---|---|---|---|---|---|---|---|
| CS1 | 0.18 | 0.26 | 0.29 | 0.29 | 0.29 | 0.27 | 0.29 | 0.29 |
| CS2 | 0.36 | 0.48 | 0.81 | 0.73 | 1.60 | 0.44 | 0.83 | 0.14 |
| CS3 | 0.23 | 0.33 | 1.50 | 1.13 | 0.43 | 1.68 | 1.98 | 2.90 |
| CS4 | 0.07 | 0.12 | 0.01 | 0.01 | 0.30 | 0.06 | 0.05 | 0.02 |
| CS5 | 0.38 | 0.28 | 0.18 | 0.42 | 0.25 | 0.16 | 0.54 | 0.13 |
| CS6 | 0.25 | 0.20 | 0.12 | 0.29 | 0.17 | 0.11 | 0.38 | 0.09 |
| CS7 | 0.25 | 0.31 | 0.22 | 0.42 | 0.06 | 0.21 | 0.08 | 0.30 |
| CS8 | 0.12 | 0.17 | 0.18 | 0.19 | 0.15 | 0.22 | 0.18 | 0.09 |
| CS9 | 0.16 | 0.18 | 0.21 | 0.21 | 0.20 | 0.19 | 0.20 | 0.20 |
| CS10 | 0.09 | 0.12 | 0.13 | 0.14 | 0.11 | 0.15 | 0.13 | 0.07 |

The Cd content in the sardines ranged from 0.09 in CS10 to 0.38 mg/kg in CS5. The Pb content in the sampled sardines ranged from 0.12 in CS4 and CS10 to 0.48

mg/kg in CS2. The Cr content in the canned sardine samples ranged from 0.01 in CS4 to 1.5 mg/kg in CS3. The Ni content in the canned sardines ranged from 0.01 in CS4 to 1.13 mg/kg in CS3. The maximum Cu content was found in CS2 and ranged from 0.06 in CS7 to 1.6 mg/kg. The Mn, Zn and Fe content were found minimum in CS4 and maximum in CS3 ranging from 0.06, 0.05 and 0.02 to 1.68, 1.98 and 2.9 mg/kg respectively.

**Table 2: Estimated Daily Intakes (EDI) (µg/kg/bw/day) of heavy metals in canned sardines.**

| | CHILD | | | | | | | | ADULT | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Cd** | **Pb** | **Cr** | **Ni** | **Cu** | **Mn** | **Zn** | **Fe** | **Cd** | **Pb** | **Cr** | **Ni** | **Cu** | **Mn** | **Zn** | **Fe** |
| CS1 | 0.25 | 0.36 | 0.40 | 0.40 | 0.40 | 0.37 | 0.40 | 0.40 | 0.06 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.10 | 0.10 |
| CS2 | 0.50 | 0.67 | 1.12 | 1.01 | 2.22 | 0.61 | 1.15 | 0.19 | 0.12 | 0.17 | 0.28 | 0.25 | 0.55 | 0.15 | 0.29 | 0.05 |
| CS3 | 0.32 | 0.46 | 2.08 | 1.57 | 0.60 | 2.33 | 2.75 | 4.02 | 0.08 | 0.11 | 0.52 | 0.39 | 0.15 | 0.58 | 0.69 | 1.01 |
| CS4 | 0.10 | 0.17 | 0.01 | 0.01 | 0.42 | 0.08 | 0.07 | 0.03 | 0.02 | 0.04 | 0.003 | 0.003 | 0.10 | 0.02 | 0.02 | 0.01 |
| CS5 | 0.53 | 0.39 | 0.25 | 0.58 | 0.35 | 0.22 | 0.75 | 0.18 | 0.13 | 0.10 | 0.06 | 0.15 | 0.09 | 0.06 | 0.19 | 0.05 |
| CS6 | 0.35 | 0.28 | 0.17 | 0.40 | 0.24 | 0.15 | 0.53 | 0.12 | 0.09 | 0.07 | 0.04 | 0.10 | 0.06 | 0.04 | 0.13 | 0.03 |
| CS7 | 0.35 | 0.43 | 0.31 | 0.58 | 0.08 | 0.29 | 0.11 | 0.42 | 0.09 | 0.11 | 0.08 | 0.15 | 0.02 | 0.07 | 0.03 | 0.10 |
| CS8 | 0.17 | 0.24 | 0.25 | 0.26 | 0.21 | 0.31 | 0.25 | 0.12 | 0.04 | 0.06 | 0.06 | 0.07 | 0.05 | 0.08 | 0.06 | 0.03 |
| CS9 | 0.22 | 0.25 | 0.29 | 0.29 | 0.28 | 0.26 | 0.28 | 0.28 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| CS10 | 0.12 | 0.17 | 0.18 | 0.19 | 0.15 | 0.21 | 0.18 | 0.10 | 0.03 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.05 | 0.02 |

As displayed in Table 2, The Estimated Dietary Intake **(**EDI) of Cd varied between 0.12 and 0.53µg/kg bw/day and 0.02 to 0.12µg/kg bw/day for the child and adults respectively. Similarly, the EDI for Pb varied between 0.17 and 0.67µg/kg bw/day and 0.04 to 0.17 µg/kg bw/day for children and adults respectively. For Cr, EDI values obtained ranged between 0.01 – 2.08µg/kg bw/day for children and 0.04 – 0.52µg/kg bw/day for adults. The EDI for Fe for consuming these canned sardines varied from 0.10 to 4.02 µg/kg bw/day for children and 0.02 to 1.01µg/kg bw/day for adults.

**Table 3: Target Hazard Quotients(THQs) of heavy metals upon consumption of canned sardine samples for child**

| | THQs | | | | | | | | ∑THQ |
|---|---|---|---|---|---|---|---|---|---|
| | **Cd** | **Pb** | **Cr** | **Ni** | **Cu** | **Mn** | **Zn** | **Fe** | |
| CS1 | 2.39 | 8.64 | 1.29 | 1.93 | 9.64 | 2.56 | 1.29 | 5.51 | 4.88 |
| CS2 | 4.79 | 1.60 | 3.59 | 4.85 | 5.32 | 4.18 | 3.68 | 2.66 | 1.11 |
| CS3 | 3.06 | 1.10 | 6.65 | 7.51 | 1.43 | 1.60 | 8.78 | 5.51 | 1.20 |
| CS4 | 9.31 | 3.99 | 4.43 | 6.65 | 9.97 | 5.70 | 2.22 | 3.80 | 1.49 |
| CS5 | 5.05 | 9.31 | 7.98 | 2.79 | 8.31 | 1.52 | 2.39 | 2.47 | 7.19 |
| CS6 | 3.32 | 6.65 | 5.32 | 1.93 | 5.65 | 1.04 | 1.68 | 1.71 | 4.80 |
| CS7 | 3.32 | 1.03 | 9.75 | 2.79 | 1.99 | 1.99 | 3.55 | 5.70 | 5.66 |
| CS8 | 1.60 | 5.65 | 7.98 | 1.26 | 4.99 | 2.09 | 7.98 | 1.71 | 3.17 |
| CS9 | 2.13 | 5.98 | 9.31 | 1.40 | 6.65 | 1.80 | 8.86 | 3.80 | 3.89 |
| CS10 | 1.20 | 3.99 | 5.76 | 9.31 | 3.66 | 1.42 | 5.76 | 1.33 | 2.32 |

**Table 4: Target Hazard Quotients(THQs) of heavy metals upon consumption of canned sardine samples for adults**

| | THQs | | | | | | | | ∑THQ |
|---|---|---|---|---|---|---|---|---|---|
| | **Cd** | **Pb** | **Cr** | **Ni** | **Cu** | **Mn** | **Zn** | **Fe** | |
| CS1 | 5.98 | 2.16 | 3.21 | 4.82 | 2.41 | 6.41 | 3.21 | 1.38 | 1.22 |
| CS2 | 1.20 | 3.99 | 8.98 | 1.21 | 1.33 | 1.04 | 9.20 | 6.65 | 2.77 |
| CS3 | 7.65 | 2.74 | 1.66 | 1.88 | 3.57 | 3.99 | 2.19 | 1.38 | 3.00 |
| CS4 | 2.33 | 9.97 | 1.11 | 1.66 | 2.49 | 1.42 | 5.54 | 9.50 | 3.72 |
| CS5 | 1.26 | 2.33 | 1.99 | 6.98 | 2.08 | 3.80 | 5.98 | 6.17 | 1.80 |
| CS6 | 8.31 | 1.66 | 1.33 | 4.82 | 1.41 | 2.61 | 4.21 | 4.27 | 1.20 |
| CS7 | 8.31 | 2.58 | 2.44 | 6.98 | 4.99 | 4.99 | 8.86 | 1.42 | 1.41 |
| CS8 | 3.99 | 1.41 | 1.99 | 3.16 | 1.25 | 5.22 | 1.99 | 4.27 | 7.91 |
| CS9 | 5.32 | 1.50 | 2.33 | 3.49 | 1.66 | 4.51 | 2.22 | 9.50 | 9.73 |
| CS10 | 2.99 | 9.97 | 1.44 | 2.33 | 9.14 | 3.56 | 1.44 | 3.32 | 5.81 |

As displayed in Table 3, heavy metals THQs values for child exposure in canned sardines ranged from 1.20 to 9.31 for Cd, 1.10 to 9.31 for Pb, 1.29 to 9.31 for Cr, 1.26 to 7.51 for Ni, 1.43 to 9.64 for Cu, 1.04 to 5.70 for Mn, 1.68 to 8.86 for Zn and1.33 to 5.51 for Fe. For adult exposure (Table 4), the heavy metals THQs values in the canned sardines ranged from 1.20 to 8.31 for Cd, 1.41 to 9.97 for Pb, 1.11 to 8.98 for Cr, 1.21 to 6.98 for Ni, 1.25 to 9.14 for Cu, 1.04 to 6.41 for Mn, 1.44 to 9.20 for Zn and 1.3 to 9.50 for Fe. The ∑THQ values of heavy metals in the canned sardines ranged from 1.11 to 7.19 and 1.20 to 9.73 for child and adult exposure respectively.

**Table 5: Quantity of Heavy metals in canned sardines reported in this study in comparison with others reports**

| Location | Fish types | No of samples | Method | Cd | Pb | Cr | Ni | Cu | Mn | Zn | Fe | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yenagoa, Nigeria | Canned sardines | 10 | AAS | 0.09-0.38 | 0.12-0.48 | 0.01-1.50 | 0.01-1.13 | 0.06-1.60 | 0.06-1.68 | 0.05-1.98 | 0.02-2.90 | This study |
| Tehran, Iran | canned tuna | 54 | GFAAS | 0.002–0.039 | 0.008–0.15 | – | – | – | – | – | – | Andayesh *et al.*, 2014 |
| Menoufia Governorate. | canned tuna | 30 | FAAS | – | 0.01–0.44 | – | – | – | – | – | – | Saad *et al.*, 2014 |
| Menoufia Governorate | Canned sardine | 30 | FAAS | – | 0.02–0.52 | – | – | – | – | – | – | Saad *et al.*, 2014 |
| Menoufia Governorate | canned mackerel | 30 | FAAS | – | 0.04–1.28 | – | – | – | – | – | – | Saad *et al.*, 2014 |
| Lisboa, Portugal | Canned Tuna | 139 | FAAS | 0.01-0.16 | ND–0.1 | – | – | – | – | – | – | Lourenço *et al.*, 2004 |
| Lisboa, Portugal | Canned Chub mackerel | 40 | FAAS | 0.03-0.04 | – | – | – | – | – | – | – | Lourenço *et al.*, 2004 |
| Lisboa, Portugal | Sardine | 113 | FAAS | 0.01-0.07 | ND–0.2 | – | – | – | – | – | – | Lourenço *et al.*, 2004 |
| Tehran, Iran | canned tuna | 5 | GFAAS | 0.03 - 0.12 | 0.18 - 0.38 | 0.90 - 1.87 | 0.58 - 1.04 | 1.29 - 2.4 | 1.20 – 2.70 | 8.34 - 36.4 | 11.2 - 28.3 | Fathabad *et al.*, 2015 |
| Benin City, Edo State, Nigeria | canned sardine and tuna | 4 | ICP-OES | – | – | – | 0.5442 – 2.1291 | – | 0.0654 - 0.2554 | 8.8931– 22.9468 | 0.2696– 10.5628 | Odiko*et al.*, 2017 |
| Iraq | canned sardines | 40 | AAS | – | – | 0.08–0.11 | 0.12-0.14 | 0.7– 2.1 | – | – | 20-30 | Jasim & Shkhaier., 2016 |
| Lublin, Poland | canned fish | 16 | ICP-MS | 0.0033–0.0754 | 0.011–0.296 | 0.500– 0.725 | 0.032–0.162 | – | 0.137– 2.566 | – | – | Kowalska *et al.*, 2018 |
| Accra, Ghana | canned fish | 15 | AAS | 0.01– 0.46 | ND–0.33 | – | – | – | – | – | – | Akomeah *et al.*, 2012 |
| Victoria Island, Lagos, Nigeria | canned fish | 20 | FAAS | ND– 0.028 | – | – | – | – | – | – | – | Babalola *et al.*, 2014 |
| Assiut, Egypt | canned tuna | 40 | AAS | 0.467-0.792 | 1.144-3.778 | ND-0.573 | 1.384-2.352 | – | – | – | – | Sharkawy *et al.*, 2020 |
| North Central Nigeria | – | 5 | AAS | 0.0091– 0.297 | 0.1051 –0.2852 | – | 0.0052–0.0573 | 0.0558-0.2329 | – | 0.0526 – 1.5472 | – | Dallatu *et al.*, 2013 |
| Tuticorin and Kanyakumari, Districts, India | Canned Fish (Mackerel, Sardine and tuna) | 6 | AAS | 0.21–0.82 | 0.13–0.97 | 0.06 -1.60 | 0.09–0.74 | 1.75-2. 63 | 0.64–0.74 | 0.25–2.84 | 0.52–2.34 | Shani, 2020 |
| Nigeria | canned sardines | 10 | GFAAS | 0.11–0.29 | 0.01–4.78 | 0.01–0.10 | 0.04–3.26 | 0.10-0.10 | 0.64–1.37 | 0.09–4.63 | 8.04–48.18 | Iwegbue *et al.*, 2009 |
| Port Harcourt, Rivers State, Nigeria | canned sardines | 27 | AAS | 1.0– 3.5 | 3.75 – 25.75 | – | – | – | – | – | 7.0– 33 | Okon *et al.*, 2020 |
| Port Harcourt, Nigeria | Canned Geisha and FountyBrand | 2 | AAS | | ND–0.0004 | ND-0.0052 | ND-0.0018 | ND-0.0033 | 0.0016-0.0028 | 0.01-0.0187 | ND-0.0379 | Iwuoha et *al.*, 2013 |
| Edo State, Nigeria | canned fish | 27 | AAS | ND– 0.82 | 0.34–1.87 | – | 2.25– 4.03 | 0.25–7.75 | 3.25–7.75 | 2.02– 9.46 | 6.21– 16.21 | Erhunmwunse & Tongo,2018 |
| Tehran, Iran | canned fish | 120 | ICP-OES | – | – | 1.65– 3.24 | 0.14– 0.37 | 0.73– 1.18 | 0.04–1.01 | – | 34.02–77.53 | Sobhanardakani *et al.*, 2017 |
| Nigeria | canned mackerel | 7 | FAAS | 0.04–0.58 | 0.05–2.82 | 0.49–3.79 | 1.33–11.33 | 0.33–0.92 | 2.30–3.84 | 1.15–7.19 | 6.45–26.90 | Iwegbue., 2015 |
| Nigeria | canned sardine | 7 | FAAS | 0.06–0.44 | 0.70–2.98 | 0.22–1.89 | <0.20–17.53 | 0.01–1.51 | 0.95– 21.78 | 3.60–17.88 | 6.06–53.54 | Iwegbue., 2015 |
| Nigeria | Canned tuna | 7 | FAAS | 0.32–0.83 | 0.23–2.56 | 0.66–14.39 | <0.20–34.21 | <0.08–1.31 | 1.65–2.33 | 1.21–5.35 | 3.06–95.78 | Iwegbue., 2015 |

## DISCUSSION

### Quantity of Heavy metals in canned sardines:

The amount of Cd in the canned sardines varied greatly (0.09 in CS10 to 0.38 mg/kg in CS5). This variation may be due to preservation techniques, manufacturing processes, storage conditions and poor packaging (Tesi *et al.,* 2020). The Cd content in canned sardines recorded in this study is within the same range as that reported by Iwegbue *et al*., (2009) (Table 5) but different from the values reported by Iwegbue *et al.* (2015) for canned sardine and tuna. Iwuoha *et al.* (2013) who examined the Cd content of canned Geisha in Port Harcourt, Nigeria, did not detect Cd in the samples.

Similar to Cd, Pb content in the sardine samples ranged from 0.12 to 0.48 mg/kg. Pb content of 0.46 to 0.55 mg/kg was reported in Jams sold in Nigeria by Jimoh and Onabanjo, (2012). The ranged reported for Pb in this study is less than that reported by Iwegbue, 2015 and Okon *et al.,* (2020) (Table 5).

The range of Cr content reported in this study (0.01 to 1.5 mg/kg) is similar to those (0.22 to 1.89 mg/kg) reported by Iwegbue (2015), but different from those reported by Sobhanardakani *et al.,* (2017) (Table 5). The permissible limit of Cu set by World Health Organization (WHO) (2001) is 2.0 mg/kg. The quantities of Cu in all the canned sardine samples examined were lesser than the WHO permissible limit. However, the range of Cu content obtained in the canned sardines from this study were higher than the range of not detected (ND) to 0.0052mg/kg reported by Iwuoha et *al.,* (2013) who analyzed heavy metal contents of Canned Geisha and FountyBrand sold in Port Harcourt, Rivers State, Nigeria.

The permissible limit of Mn set by World Health Organization (WHO) (2001) is 5.0 mg/kg. The content of Mn in all the canned sardine samples evaluated in this study (0.06 to 1.68 mg/kg) were below the WHO permissible limit. The Mn content obtained in this study was similar to those reported by Iwegbue (2015). Conversely to

values obtained in this study for Fe and Zn content of the examined canned sardines were higher than the WHO allowable limits of 1.0 mg/kg and1.5 mg/kg respectively. Zn and Fe content in this study ranged from 0.05 and 0.02 to 1.98 and 2.9 mg/kg respectively and are similar to values reported by Iwegbue *et al.,* 2009 (for Zn) but different from the report of Iwegbue (2015) (for Zn and Fe).

**Estimated daily intakes (EDI), Target Hazard Quotients and Total Target Hazard Quotients:**

The EDI in most of the samples for children exposure were lesser than Ni acceptable daily intake (TDI) of 12μg/kg bw/day (WHO, 2008). The suggested daily intake (RDI) of Cr is 200 μg/day (WHO, 2013) whilst that of Co is 1.7 μg/kg bw/day for a 60kg adult). The EDI of Cr in this study was beneath the RDI value. The TDI of Cu is 83 μg/kg bw/day for an adult) (Iwegbue, 2015). The EDI of Cu in these samples was lower than the TDI of Cu for children exposure. The EDI of Mn in the samples was higher than the RDI of Mn for children and adults (Iwegbue , 2015).

The THQ and ΣTHQ values are shown in Table 3 and 4. The THQ values for Pb, Cd and Zn and ΣTHQ were > 1 in the sampled canned sardines for children exposures while those of Ni, Cr and Mn were < 1. This suggests presence of wellbeing risk for individuals eating these canned sardines regularly.

It must be noted that the THQ values do not provide a quantitative estimate of the probability of an exposed population experiencing a reverse health effect, but they rather serve as an indication of the risk level due to metal exposure (Kalogeropoulos *et al*., 2012; Storelli, 2008). The interpretation of the THQ value is binary; THQ is either>1 or<1. When the THQ>1 it indicates a reason for health concern (Naughton and Petroczi, 2008; Hague *et al*., 2008). THQ values are additive, they are not multiplicative, e.g. the level of concern at a THQ of 20 is larger but not tenfold that at a THQ of 2.Because of the possible synergistic

effects of metals, the individual THQ values of the metals were summed up to give the Total Target Hazard Quotient (PTHQ) which is also interpreted in a similar manner to the THQ.

## CONCLUSION

The quantity of metals in the canned sardines varied. While metals such as Cd and Pb concentrations were above their permissible limits others like Mn and Co were below the limits in the canned sardines. The EDI values indicated that the intakes of metals from the consumption of these food items were within their provisional tolerable daily intake limits for the toxic metals and recommended daily intake values for the essential metals. However, too much consumption of these products could lead to exposure to high amounts of metals, therefore parental guidance is required to control the eating of canned sardines by children.

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