**ASSESSMENT OF HEAVY METAL CONTAMINATION AND HEALTH RISK ASSOCIATED WITH CONSUMPTION OF CANNED FISH IN JOS, NIGERIA**

**ABSTRACT:**

Environmental pollution with toxic metals can lead to possible contamination of the food chain. Fish consumption is essential for human nutrition, but exposure to heavy metals through fish can pose significant health risks. This study investigates the levels of heavy metals (Pb, Cd, Hg, As, Ní, Cu, Zn, Co and Cr) in canned fish commonly consumed in Jos, Nigeria and potential health risks. Heavy metal in canned fish were analyzed using standard techniques. The mean concentration of these metals’ ranges from Cd (0.052 – 0.295), As (0,015 – 0.166), Pb (0.001 – 0.173), Ni (0.023 – 0.086), Co (0.012 – 0.192), Hg (0.002 – 0.040), Zn (2.090 – 12.010), Cu (2.100 – 8,030) and Cr (0.100 – 4.010) in mg/kg. The estimated daily intake was all less than one except for Zn in sample A, B, C, E and H which have the values of 1.6598, 1.2635, 1.8804, 1.2056 and 1.7239 with Co having the value of 1.3573. The risk assessment due to potential exposure level showed that there was no health risk associated with these elements through consumption of this canned fish as the target hazard quotient (THQ) and total target hazard quotient (TTHQ) all had values of less than one for all the metals, which revealed non-carcinogenic risk. However, constant monitoring of these metals is recommended to avoid accumulation which may lead to potential risk to human as a result of consumption of canned fish. Particularly due t As, Cd, Hg, and Pb.

Keywords: Canned fish, carcinogenic, health risk, heavy metals.

**INTRODUCTION:**

Fish and fishery products are a vital source of essential nutrients, playing a crucial role in maintaining diverse and health diets. (FAO, 2012) Despite these fish can sometimes also endanger consumers health due to the occurrence of chemicals (heavy metals, pesticides, PAHs, dioxins), physical (metal, glass, plastic), and biological (biotoxins, bacteria, viruses, parasites) hazards (Vergis *et al,* 2021). Heavy metals by definition have densities greater than 5gcm3 are notable pollutants, environmental food contaminant. This risk from the group of industrial pollutants includes over all heavy metal (lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), zinc (Zn), copper (Cu), nickel (Ni), tin (Sn) increasing toxic metal content in aquatic products has turn out to be a universal burden due to the danger to aquatic organisms and human health associated with the intake of these products (Arumugam *et al,* 2020).

Heavy metal has harmful impact on many organisms and can bioaccumulate in the human body and in the ecosystem, fish and various aquatic organisms can even be utilized as environmental tracking for heavy metal pollution (Younis, *et al,* 2021). Heavy metals as a native component in the Earth’s crust cannot be degraded or destroyed. Their presence in food is almost very frequently certain and they enter the human body through food, drinking water and air.

Fish and vegetables are the main sources of cadmium for humans due to their high accumulation capability (Irfan et al, 2021) meanwhile liver is the main accumulator organ for heavy metals (Anandkamor *et al,* 2018). Species residing in the lower zone of the water column and carnivorous and/or omnivorous species show the highest level of heavy metal (Sheikhzadeh & Hackham, 2021). The presence of toxic elements in fish can be hazard for human health especially the Mediterranean countries and other region with high percapita-fish consumption (Roberto *et al*, 2018).

Food insecurity is a widespread issue across many African nations, making them to be the net importer of fish in terms of volume. The Nigeria population which is estimated to be growing at 2.41% annually depends massively on fish to meet the over 40% animal protein intake needs of its population. Demand for fish from industrial fishing countries around the world in the form of frozen and canned fish is valued at about 500million US dollars or 250billion Nigeria naira per annum.

Canned food are popular food sources all around the world and it is a modern technological advancement in food processing, helps to increase shelf life and allow storage for several years. Most of the marine fish are canned, thus making it more available for consumption by humans living far away from sea sites. Fish are constantly exposed to chemicals in polluted and contaminated water; therefore, the aim of this work is to access the presence of heavy metals in canned fish in Jos and health risk associated with consuming this product.

**MATERIALS AND METHODS**

**MATERIALS.** All reagents used to include HNO3, H2O2 and others are of analytical grade obtained from Merck Scientific Germany through their representative in Nigeria.

**SAMPLE COLLECTION AND PREPARATION**

The samples of eight canned fish mainly (Mackerel, tuna and sardine, species) were purchased randomly from various market in Jos metropolis. A minimum of five different brands of each of the eight canned fish samples were obtained at random from various market, after collection, combination of each of these canned brands, were prepared and homogenized in a stainless-steel blender cup. Their 100g test portions were stored at -200C. Then all the samples were freeze-dried for 48 h until constant weight was obtained and sealed in airtight plastic bags (Islam and Mustafa, 2023). A 4 g portion of each canned fish sample was accurately weighed and transferred to a Teflon digestion vessel, where it was mixed with 15 cm3 of pure nitric acid. The samples were then microwaved as presented. Step 1. 250C for ten minutes at 1000 W; Step 2: 960C for 30 minutes; Step 3: 1800C for ten minutes at 1000 W; 1800C for ten minutes before cooling to room temperature, Step 4: 2 cm3 of 30% hydrogen peroxide was added, and the mixture was exposed to step 3.

In the final step, hydrogen peroxide was used to break down organic materials that may have remained undissolved throughout the pure nitric acid digestion (Steps 1- 3). Finally, the digests were prepared in acid-washed standard flasks to 25cm3 with deionized water and placed in acid-washed 50cm3 polyethylene bottles. All the metal concentration were determined using atomic absorption spectrophotometer (AAS) as described (AOAC, 2005).

**DETERMINATION OF HEALTH RISK DUE TO METAL CONTAMINATION**.

***Estimated daily intakes***. Estimated daily intakes (EDI) for potentially toxic elements were calculated by multiplying the respective average concentration in fish samples by the weight of food item consumed by a person (body weight of 70 kg for an adult in Nigeria), as obtained WHO and then using the formula (Shaheen et al, 2016)

EDI = (FIR x C)/BWT - - - - - - - - - - - - - - - - - - - ------------------------------------------ 1

Where EDI is the estimated daily intakes, FIR is the food ingestion rate, kg/person/day, C is the metal content in fish samples, mg/kg, BWT is the body weight for adult 70 kg on a weight basis, the daily consumption of fish is 10.96 kg. (FAO, 2018).

***Non-carcinogenic risk***: The assessment of non-carcinogenic risks followed the guidelines outlined in the risk-based concentration Table published by the United States Environmental Protection Agency (USEPA) region III (USEPA, 1999 P98).

The target hazard quotient (THQ) was employed to evaluate and quantify the non-carcinogenic health risks associated with consumption of specific metals in fish (USEPA risk-based concentration Table). It represents the ratio of exposure to a single substance over a defined time (e.g. sub-chronic) to reference dose (RfD) for that substance derived from a similar exposure period. The target hazard quotient (THQ) was calculated using the following equations.

THQ = [(EFr x ED x FIR x C)/RfD x BWT x AT] x 10-3 - ------------------------------------- (2)

Total THQ (TTHQ) = THQ toxicant 1 + THQ toxicant 2 + - - - - - - -THQ toxicant n ---------- - - - - (3)

Where THQ is the target hazard quotient, EFr is the exposure frequency (365days/year), ED is the exposure duration, FIR is the food ingestion rate (10.96kg/person/day), C is the metal concentration in fish in mg/kg, RfD is the oral reference dose in mg/kg/day, the oral reference dose for Cd, As, Pb, Ni, Co, Hg, Cu, Zn and Cr are 0.001, 0.003, 0.0035, 0.02, 0.0014, 0.0001, 0.04, 0.3 and 0.003 respectively (USEPA) AT is the average time for non-carcinogen (365 days/year multiply by number of exposure years. The target hazard quotient (THQ) ≥ 1 indicate potential health risks necessitating interventions and protective measures (Wang et al, 2005 and Islam et al, 2016)

***Carcinogenicity Risk (CR)***: This was calculated as the lifetime probability of developing cancer due to prolonged exposure to a potential carcinogen (USEPA, 1999). The carcinogenic risk of Arsenic, Lead, Cadmium and Mercury consumption was calculated using the method outlined by USEPA Region III risk-based concentration Table.

CR = [EFr x ED x FIR x C x CSFo/BWT x AT] x 10-3 -------------------------------------------- (4)

Where EFr is the exposure frequency (365 days/year), ED is the exposure duration (70 years USEPA region screening level summary Table November 2011), AT is the average time for carcinogen (365 days/year’s multiply by 70 years), CSFo was 1.5, 0.3 and 0.38 mg/kg/day for As, Hg and Cd respectively from the integrated risk information system (Risk-Based concentration Table). Total As, Cd and Hg in marine food (fish) is mostly organic and a little amount may remain as inorganic. In this work we assumed the conversion coefficient of total As, Cd and Hg to inorganic As, Cd and Hg by 0.05, 0.8, and 0.5 in fish to produce a carcinogenic risk.



**RESULTS AND DISCUSSION**

The resultsof the concentration of heavy metals, estimated daily intake, non-carcinogenic (target hazard quotient and total hazard quotient) is represented in Table 1, 2 and 3 while the carcinogenic risk computed for As, Cd and Hg is presented in Table 4. From the results in Table 1, the concentration of Cd, As, Pb, Co, Hg are less than 1.00 mg/kg in all the samples of canned fish investigated in Jos, but Zn and Cu had values greater than 1.00 mg/kg with average values ranged between 2.090 – 11.010 mg/kg in samples studied for Zn and 2.100 – 8.030 mg/kg for Cu while Cr has the value of 1.422 mg/kg in sample A. Sample H had the highest value for Zn (11.010 mg/kg) and least value of 2.090 mg/kg in sample G. This higher value reported for Zn is good since Zn is an essential mineral that plays a crucial role in various body functions such as immune function, wound healing and protein synthesis and this will support the overall health and well-being. Even though the recommended value of daily intake of Zn varies by age, sex and other factors, the adequate intake for Zn is between 8.00 – 11.00 mg/kg for adult women and 11.00 – 12.00 mg/kg for adult men, comparing these results with that of Table 2 there is low estimated daily intake of Zn in canned fish consumed in Jos. This result for Zn in canned fish agreed with other reported earlier the value for Zn in canned fish between 2.090 – 11.00 mg/kg (Adewumi *et al*, 2014, Ikem *et al*, 2004, Kosker, *et al* 2023). The values for Cu ranged from 2.10 mg/kg to 8.030 mg/kg, this values are within the FAO/WHO guideline limit of 30 mg/kg, Cu is necessary is the body for the production of collagen, a protein that gives structure to connective tissue, bones, skin, and blood vessels, other important of Cu includes immune system function by aiding in the production of white blood cells which fight off infections, antioxidant which help protect cells from damage caused by free radicals, synthesis of neurotransmitter such as dopamine and serotonin which are essential for brain function and development, energy production which Cu plays a role in the production of ATP, the energy currency of the body. Cu also helps in iron metabolism, bone health, cardiovascular health and wound healing among many others. The values reported for Cu here is in agreement with the values reported by other investigators in their work (Shafi*, et al*, 2023 and Silva, *et al,* 2018). For other element like Cd, the values reported for samples F and G with the values 0.137 and 0.119 mg/kg as indicated in Table 1are more than the recommended value of 0.1 mg/kg by FAO/WHO 2006, consuming canned fish with these values over a period of time can result to health complications such as kidney damage, gastrointestinal disorder while long time consumption can lead to kidney disease, bone disease, cancer risk, neurological effects and reproductive issues. The results of Cd in samples F and G confirmed with earlier reported (Caroli *et al*, 2020, Asim *et al*, 2023, and Carlos, *et al*, 2019) who also reported the values of Cd in canned fish to be between 0.12 – 0.42 mg/kg. All others metals studied are within the guideline limits of FAO/WHO 2006.

**HEALTH RISK ASSESSMENT**.

The health risks due to the consumption of canned fish with these metals were assessed through estimated daily intake and carcinogenic risk, the estimated daily intake values for all the metals investigated were less than 1.00 mg/kg as reported in Table 2 indicating the exposure level is below the tolerable daily intake or the reference dose established by the regulatory agencies. Meaning there is no health hazard in consuming this fish., the total target hazard quotient also agreed with this based on the results indicated in Table 3 with the values less than one for all the metals assessed While the carcer risk assessment of As, Cd, and mercury revealed Cd has the values ranged from 1.13 x 10-3 to 6.41 x 10-3, this value pose for a concern as compare with the regulatory value of < 10-4 for low risk, 10-4 to 10-3 for moderate risk and > 10-3 high risk, it could be suggest there is high risk of cadmium in consuming this canned fish. Also, the values for As and Hg reported here in Table 4 are higher than the values set by the regulatory body (EPA, 2005), this suggests cancer risk associated with As and Hg in consuming this canned fish.

**CONCLUSION**

The results of the assessment of heavy metals contamination and health risk associated with the consumption of canned fish in Jos reaved metals such as Pb, Ni, Hg, Zn, Cu and Cr are having concentration within the regulatory guideline values while Cd, and As, need to be monitor regularly as their concentration in the samples F, G for Cd, and B, C,F, and H for As are slightly higher than the guideline limits meaning consumption of canned fish with these values over a long period can result to chronic effects of diseases cause by these metals., hence constant monitoring of the levels of heavy metals in canned fish is recommended in order to improve the health of the consumer..

**DECLARATION**

The authors declare that they have no conflict of interest related to the publication of this manuscript and approved its submission for publication.

**REFERENCES**

Adewumi A. A., Adewole. H. A., Olaleye, V. F (2014) Proximate and elemental composition of the fillets of some fish species in Osinno Reservoir: Nigeria. Agriculture and Biology *Journal of north America 5(3) 109- 117*

Anandkumar A, Nagarajan R, Prabakaran K, Chua Han Bing, and Rajaram R (2018) Human health risk assessment and bioaccumulation of metals in fish species collected from the Miri coast, Sarawak, Borneo. Marine Pollution bulletin DOI: [10.1016/j.marpolbul.2018.06.033](https://doi.org/10.1016/j.marpolbul.2018.06.033)

Anandkumar Arumugam, Jian Li, Prabakaran Krishnamurthy, Zhang Xi Jia , Zhanrui Leng , Nagarajan Ramasamy, Daolin Du (2020) Investigation of toxic elements in Carassius gibelio and Sinanodonta woodiana and its health risk to humans *Environ Sci Pollut Res Int.* *;27(16):19955-19969. doi: 10.1007/s11356-020-08554-1. Epub 2020 Mar 30.*

Anandkumar, A., Nagarajan, R., and Rajendran, R. (2018) Liver as the main accumulation organ for heavy metal in fish. *Toxicology Reports 5, 591 – 596.*

Arumugam, R, Narasimhan, R., and Ramachandran, S. (2020). Toxic metal content in aquatic products. A universal burden. *Journal of Environmental Sciences, 96, 342 – 353*.

Asim Najmi, Mohammed Albratty, Abdul Jabbar Al-Rajab, Hassan A. Alhazmi, Sadique A. Javed, Waquar Ahsan, Zia ur Rehman, Rym Hassani, and Saad S. Alqahtani. (2023) Heavy Metal Contamination in Leafy Vegetables Grown in Jazan Region of Saudi Arabia: Assessment of Possible Human Health Hazards *International Journal of Environmental Research and Public Health 20, 2984. https://doi.org/10.3390/ ijerph20042984*

Association of Official Analytical Chemists (AOAC), (2005). Official methods of analysis (18th ed.) Gaithersburg MD: AOAC International.

Carlos Alberto da Silva, Silvia de Oliveira Santos, Carlos Alexandre Borges Garcia, Gabriela Cugler de Pontes & Julio Cesar Wasserman (2019) Metals and arsenic in marine fish commercialized in the NE Brazil: Risk to human health: Human and Ecological Risk Assessment: An International Journal

Caroli, Monica De, Antonella Furini, Giovanni Dal Corso, Makarena Rojas, and Gian-Pietro Di San Sebastiano (2020) Endomembrane Reorganization Induced by Heavy Metals Plants 2020, 9, 482; doi:10.3390/plants9040482

Food and Agriculture Organization of the United Nations (2012) State of the world’s fisheries and aquaculture 2012

Food and Agriculture Organization of the United Nations (2018). The state of the world’s fisheries and aquaculture

Food and Agriculture Organization of the United Nations/World Health Organization (2006). Safety evaluation of certain contaminants in food.

Ikem, A., and Egiebor, N. O, (2005) Assessment of trace elements in canned fishes (Mackerel, tuna, salmon, sardine and herrings) marketed in Georgia and Alabama. *Journal of food composition and Analysis 18, 771-787*

Irfan, M., Khan, A., Khan, S., and Alam, M. (2021). Fish and vegetables: Main sources of cadmium for humans due to their accumulation capability. *Environmental Science and Pollution Research, 28(10), 12441 – 12452*

Islam MS, Mustafa RA. (2023) Assessment of trace elements in canned fish and health risk appraisal. *Foods and Raw Materials.;11(1):43–56.*

Islam, M. S., Ahmed, M. K., Habibullah- Al-Mamun, M., Ali, M. M., Eaton, D.W. (2016) Health risk assessment due to heavy metal exposure from commonly consumed fish and vegetables. *Environment systems and decisions 36(3) 253-265.*

Kosker, A. R., Gundogdu, S., Esatbeyoglu, T., Aya, D., and Ozogul, L. (2023) Metal levels of canned fish sold in Türkiye: health risk assessment*. Frontier Nutrition 10: 1255857*,

Rana MM, Asdari R, Chowdhury AJ, Munir MB. (2023) Heavy metal contamination during processing of canned fish: a review on food health and food safety. Desalination and Water Treatment. 2023 Dec 1; 315:492-499. DOI: 10.5004/dwt.2023.30015

Roberto Merciai, Conxi Rodríguez-Prieto, Jordi Torres, Margarida Casadevall (2018) Bioaccumulation of mercury and other trace elements in bottom-dwelling omnivorous fishes: The case of Diplodus sargus (L.) (Osteichthyes: Sparidae*) Marine Pollution Bulletin* *136, 10-21*

Shafi, J., Mirza, Z. S., Kosour, N., and Zatarullah, M. (2023) Assessment of Heavy metals content in organs of edible fish species of River Ravi in Pakistan. *Journal of Animal; & Plant Sciences 33(1) 201-210*

Shaheen, N., Irfan, N. M, Khan, I. N, Islam, S, Islam, M. S and Ahmed M. K. (2016). Presence of heavy metals in fruits and vegetables: Health risk implications in Bangladesh *Chemosphere 152: 431-438*

Sheikhzadeh, H and Hamidian, A. H. (2021) Bioaccumulation of heavy metals in fish species of Iran: A review: *Environmental Geochemistry and health 43(10) 3749-3869*

United States Environmental Protection Agency (1999). Guidance for assessing chemical contaminant data for use in fish adversaries. Washinton, DC

United States Environmental Protection Agency (2005). Guidelines for carcinogen risk assessment Washington DC (EPA 630/P-03/001F)

Vergis, J., Rawool, D., Malik, SV S., and Barbuddne, S (2021) Food safety in fisheries: Application of One Health approach *Indian J Med Res 153, 348-357* DOI: 10.4103/ijmr.IJMR\_573\_21

Wang, X., Sato, T., Xing, B. and Tao, S (2005). Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. *Science of Total Environment 350(2005) 28-37*

Younis, E. M., Abdel-wanith, A. W., Al-Asgah, N. A., Elthebite, S. A and Rahman, M. (2021) Nutritional value and Bioaccumulation of heavy metals in muscle tissues of five commercially important fish species from the red sea. *Saudi Journal of Biological sciences 28(3) 1860-1866*