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Research Article

Evaluation of Heavy Metal Content of Canned Fishes and Selected Locally Consumed Fishes Sold in Nigerian Market

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Abstract

Fish is mostly consumed in many parts of the world by human population, as it provides nutrients of high biological value. Fish is a highly perishable commodity and that is why various processing methods are applied to safeguard it for use. Most of these processing methods can predispose fish to certain heavy metals that maybe detrimental to health and well-being of the human.

There are increased global reports on heavy metals contamination of food samples especially imported fish and this phenomenon has raised lots of concerns among nutritionists and health workers, and environmental toxicologist. Hence, the aim of this research work is to evaluate the quantities of heavy metals; Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg) and Arsenic (As) present in canned fishes and selected local fish samples in Nigeria. Heavy metals were determined using UNICAM 939 Atomic Absorption Spectrophotometer at different wavelengths. The results shows that cadmium content was generally low in all the samples ranging from 0.0024 - 0.0099 ppm while the local fishes showed the highest amount ranging from 0.0074 - 0.0099 ppm. Lead content ranged from 0.017 - 0.026 ppm. The local fish samples tend to have lower lead levels while the canned fishes had higher level of lead in their tissues. The result also shows that chromium content was generally high in all the samples ranging from 0.037 - 0.058 ppm while the selected fishes show the lowest amount ranging from 0.027 - 0.031 ppm. Mercury levels were present in some selected fishes ranging from 0.0037 - 0.0046 ppm while the canned ones had mercury level in the range of 0.0022 - 0.0039 ppm. The highest mercury level (0.0046 ± 0.01) was observed in sample 3, a locally consumed freshwater fish. The level of arsenic in all the samples ranged from 0.0079 - 0.015 ppm. Hazard quotient result shows that the HQ was less than 1 (< 1) generally for all the samples except for Cr level that was greater than 1 (> 1) in sample numbers 11 and 14 with HQ of 1.02 and 1.16 respectively. Therefore, the risk of exposure to majority of the tested samples shows that adverse effects are not likely to occur except for samples number 11 and 14. The levels of these heavy metals in the fish samples were below tolerable and permissible level which may not pose any harm to consumers. However, nutrition education will help to create awareness as well as protecting consumers against heavy metals bioaccumulation in the body.

Keywords: *Heavy Metals; Canned Fish; Hazard Quotient*

Introduction

Fish is one of the most important foods in human diet because of its high nutritional quality [18]. The need for high quality fish and fishery products is growing considerably every year mostly due to their nutritional fact that they contain many beneficial healthy substances [5]. The most important of these are fish lipids, which usually contains high amount of omega-3 fatty acids, mainly α-linolenic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA). The omega-3 fatty acids have several beneficial impacts on human health [18]. In many low-income countries with water and fishery resources, fish is important for livelihoods, income and as food for the rural poor who suffer disproportionately from undernutrition, including micronutrient deficiencies [5].

Heavy metals are generally defined as metals with relatively high densities, atomic weights, or atomic numbers [18]. In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Heavy metals can be classified as potentially toxic (arsenic, cadmium, chromium, lead, mercury), probably essential (nickel, vanadium, cobalt) and essential (copper, zinc, selenium) [14]. Canning is one of the various food processing and production methods, designed to prolong the shelf life of food stuffs. Contact between food and the coat metal surface of packing containers or the processing equipment is a significant source of toxic contamination in food.

Contamination of food products by heavy metals is becoming an unavoidable problem these days [20]. Apart from the threat from polluted environment, canned food is subjected to heavy metal contamination during the canning process [8]. Solder used in the manufacture of cans has been recognized as a source of lead contamination during canning [20]. The consumption of canned fish is widely spread in the world today because it is convenient and affordable for most families.

Statement of problem

There has been growing interest in determining heavy metals in the marine environment and attention has been drawn to the measurement of contamination levels in food supplies particularly fish [2]. Toxic heavy metals can be very harmful even at low concentrations when ingested over a long period of time, this is because they are non-degradable, and they bio accumulate in the human body. The effect of this bioaccumulation predisposes humans to several public health diseases such as renal, cardiovascular, neurological, and gastrointestinal problems among others.

Materials and Methods

The twelve (12) brands of canned fish and three (3) selected fish samples were washed under running tap water, cut open and mashed with a plastic mortar and pestle after which 100g of each sample was put in an airtight plastic container and stored at a temperature of -2°C and transported to the laboratory for analysis.

Determination of heavy metals: The samples were mashed using plastic mortar and pestle. One (1g) each of the sample was weighed into a round bottom flask. Three (3) spatula of anti-bump granules was added. 50 mls of 2 molar HNO_3 was added. It was then put into an electro-thermal heater and allowed to concentrate for 1 hour. The sample was then poured into 100 ml volumetric flask and distilled water was added up to the mark. The digested samples were then taken to the UNICAM 939 Atomic Absorption Spectrophotometer for heavy metal determination. The method involved direct aspiration of the sample into an acetylene flame ignited by a yellow cathode lamp at specific wavelength:

- Arsenic ASTM D 3972.
- Cadmium ASTM D 3557.
- Chromium ASTM D 1667.
- Lead ASTM D 3559.
- Mercury ASTM D 3223.

Determination of hazard quotient (HQ): A hazard quotient is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. It is primarily used to determine the health risks of toxic substances like heavy metals, pesticides, drugs etc. A hazard quotient less than or equal to 1 indicates that adverse effects are not likely to occur, and thus can be considered to have negligible hazard. HQs greater than 1 are not statistical probabilities of harm occurring. Instead, they are a simple statement of whether (and by how much) an exposure concentration exceeds the reference concentration (RfC).

Results

Concentration of cadmium and lead levels in canned and selected fish samples in Nigeria

Samples	Cadmium (ppm)	Lead (ppm)
1	0.0056 ± 0.01	0.019 ± 0.01
2	0.0081 ± 0.01	0.021 ± 0.01
3	0.0088 ± 0.01	0.025 ± 0.01
4	0.0099 ± 0.01	0.017 ± 0.01
5	0.0065 ± 0.01	0.026 ± 0.01
6	0.0079 ± 0.01	0.018 ± 0.01
7	0.0049 ± 0.01	0.027 ± 0.01
8	0.0063 ± 0.01	0.016 ± 0.01
9	0.0061 ± 0.01	0.019 ± 0.01
10	0.0059 ± 0.01	0.020 ± 0.01
11	0.0024 ± 0.01	0.023 ± 0.01
12	0.0074 ± 0.01	0.022 ± 0.01
13	0.0039 ± 0.01	0.019 ± 0.01
14	0.0084 ± 0.01	0.027 ± 0.01
15	0.0066 ± 0.01	0.022 ± 0.01

Table 1: *Cadmium and lead levels in canned and some selected fish samples.*

Table 1 shows the results of cadmium and lead levels in canned and selected fish samples collected from ogige market. The result shows that cadmium content was generally low in all the samples ranging from 0.0024 - 0.0099 ppm sample while the local fishes showed the highest amount ranging from 0.0074 - 0.0099 ppm.

The results of lead content in fish samples analyzed ranged from 0.016 - 0.027 ppm. The level of lead in the analyzed samples showed that the local fish samples tend to have lower lead levels while the canned fishes had higher level of lead in their tissues.

Concentration of chromium, mercury and arsenic levels in canned and selected fish samples in Nigeria

Samples	Chromium (ppm)	Mercury (ppm)	Arsenic (ppm)
1	0.043 ± 0.01	0.0039 ± 0.01	0.011 ± 0.01
2	0.046 ± 0.01	0.0022 ± 0.01	0.012 ± 0.01
3	0.031 ± 0.01	0.0046 ± 0.01	0.0079 ± 0.01
4	0.034 ± 0.01	0.0045 ± 0.01	0.0087 ± 0.01

5	0.049 ± 0.01	0.0029 ± 0.01	0.013 ± 0.01
6	0.041 ± 0.01	0.0030 ± 0.01	0.011 ± 0.01
7	0.037 ± 0.01	0.0032 ± 0.01	0.0097 ± 0.01
8	0.032 ± 0.01	0.0031 ± 0.01	0.0083 ± 0.01
9	0.037 ± 0.01	0.0029 ± 0.01	0.0095 ± 0.01
10	0.046 ± 0.01	0.0027 ± 0.01	0.012 ± 0.01
11	0.051 ± 0.01	0.0035 ± 0.01	0.013 ± 0.01
12	0.027 ± 0.01	0.0037 ± 0.01	0.010 ± 0.01
13	0.047 ± 0.01	0.0037 ± 0.01	0.012 ± 0.01
14	0.058 ± 0.01	0.0039 ± 0.01	0.015 ± 0.01
15	0.040 ± 0.01	0.0036 ± 0.01	0.010 ± 0.01

Table 2: *Chromium, mercury and arsenic levels in canned and selected fish samples.*

Table 2 shows the results of chromium, mercury and arsenic levels in canned and selected fish samples collected from ogige market. The result shows that chromium content was generally high in canned fishes ranging from 0.037 - 0.058 ppm sample while the selected fishes showed the lowest amount ranging from 0.027 - 0.034 ppm. However, sample 14 had the highest levels of chromium 0.058 ± 0.01 while sample 12 had the lowest level of chromium 0.027 ppm.

Similarly, mercury levels were present in some selected fishes ranging from 0.0037 - 0.0046 ppm while the canned ones had mercury levels in the range of 0.0022 - 0.0039 ppm. The highest mercury level (0.0046 ± 0.01) was observed in sample 3, a locally consumed freshwater fish.

The level of arsenic in all the samples ranged from 0.0079 - 0.015 ppm. The selected fish samples show the lowest level while the canned fishes show higher values.

Samples	HQ Cd	HQ Pb	HQ Cr	HQ Hg	HQ As
1	0.112	0.06	0.86	0.0078	0.11
2	0.162	0.07	0.92	0.0044	0.12
3	0.176	0.08	0.62	0.0092	0.079
4	0.198	0.06	0.68	0.009	0.087
5	0.13	0.09	0.98	0.0058	0.13
6	0.158	0.06	0.82	0.006	0.11
7	0.098	0.09	0.74	0.0064	0.097
8	0.126	0.05	0.64	0.0062	0.083
9	0.122	0.06	0.74	0.0058	0.095
10	0.118	0.07	0.92	0.0054	0.12
11	0.048	0.08	1.02	0.007	0.13
12	0.148	0.07	0.54	0.0074	0.1
13	0.078	0.06	0.94	0.0074	0.12
14	0.168	0.09	1.16	0.0078	0.15
15	0.132	0.07	0.8	0.0072	0.1

Table 3: *Hazard quotient of Cd, Pb, Cr, Hg and as in canned and locally consumed fish samples in Nigeria.*

Hazard quotient was calculated for all the samples (Table 3). The result shows that the HQ was less than 1 (< 1) generally for all the samples analyzed except for Cr level that was greater than 1 (> 1) in sample numbers 11 and 14 with HQ of 1.02 and 1.16 respectively. Therefore, the risk of exposure to majority of the tested samples shows that adverse effects are not likely to occur except for samples number 11 and 14. The levels of these heavy metals in the fish samples may not pose any harm.

Discussion

Cadmium: Cadmium is the seventh most toxic heavy metal according to Agency for Toxic Substance and Disease Registry (ASTDR) ranking. Once it gets absorbed by humans, it will accumulate inside the body throughout life. The cadmium content of the selected fish samples is highest particularly sample 4 (0.0099 ppm). According to [13] "cadmium levels present in liver and kidneys of marine mammals may result in a particularly high intake of cadmium". The canned fish samples have lower cadmium levels ranging from 0.0024 - 0.0084 ppm. Though, the levels of cadmium in both canned and some selected fish samples did not exceed the FAO/WHO permissible daily tolerable intake of cadmium which is 0.2 ppm.

Lead: The exposure to lead (pb) either through food, water and air has been reported by many researchers [11]. The canned fish samples have higher lead levels as can be seen in sample 7, 14 and 5 this is in accordance with the findings of [20], that solder used in the manufacture of cans, has been recognized as a source of lead contamination during canning. The lead levels of the local fish samples are low ranging from 0.017 - 0.025 ppm. 71 despite the higher levels of lead in canned fish, the FAO/WHO permissible daily tolerable intake of 0.3 ppm was not exceeded. If Nigeria can increase the production of fish locally, the importation of fish may reduce and in the long run help in protecting the consumers who may be eating lead (Pb) loaded fishes.

Lead toxicity can be very dangerous because it can cause neurotoxicity, which is particularly severe during the first two to three years of life when early development of the central nervous system occurs. Exposure to lead during this time increases the risk of mild mental retardation, attention deficit hyperactivity [12]. Its absorption may disrupt various biochemical reactions and cellular structures [22]. Its toxicity causes gastrointestinal and neurologic signs depending on the affected species and duration of exposure. Abdominal pain and gastrointestinal signs such as diarrhea are the initial clinical manifestations when exposed to excessive amounts of lead, and neurologic signs such as depression, ataxia, seizure, and even death typically follow [22].

Chromium: The analyzed fish samples showed that chromium content was generally high in all canned samples ranging from 0.032 - 0.058 ppm while the selected fishes should the lowest amount ranging from 0.027 - 0.034 ppm. According to [6], chromium is released into the environment through sewage and fertilizer, which leach into the marine environment accumulate and in due cause transferred to fishes, studies by [16] in [9] shows that when fish are exposed to elevated metal levels in an aquatic environment, they can absorb the bioavailable metals directly from the environment through the gills and skin or via the ingestion of contaminated water and food, thus accumulates them in their tissues and enter the food chain.

Mercury: The results obtained from this research showed that mercury (Hg) was present in all the samples ranging from 0.0037 - 0.0046 ppm in some selected fish samples while the canned fishes had mercury level in the range of 0.0022 - 0.0039 ppm. The highest mercury level (0.0046 ppm) was observed in sample 3, a locally consumed freshwater fish, this result was however expected because mercury (Hg) contamination of fishes has been globally reported. Mercury, a dangerous heavy metal has been in for various purposes in agriculture, medicine, industries etc. for a long time. Hence the likelihood of this metal contaminating food and aquatic organisms including fish is very high [7,15,17,25]. Similarly, a lot of farming activities where pesticides and other agrochemicals are utilized are ongoing along the shore of this River. The possibility of spillage or leakage into the soil and consequently into the water bodies by run-off activities is inevitable.

Toxicity of methylmercury is high with the nervous system as a major target. Consumption of Mercury (Hg) contaminated fish either canned or local gives more reasons to worry due to their effect on health. Although Mercury (Hg) was also present in the selected fish samples, its presence may be due to the practice by farmers where they use some chemicals in the cropping of fishes. To reduce or eliminate Mercury (Hg) in our local fishes, farmers should be properly educated on the toxicity implication of using chemicals to harvest fish. An estimated 850,000 Nigerians are prone to cancer according to [24]. This report was based on exposure to mercury through mining activities, however the burden of Mercury (Hg) consumption of contaminated fish may double this factor if adequate measure is not employed. Mercury toxicity has been demonstrated at low exposure levels, exposure to this compound should therefore be minimized while recognizing that fish constitutes an important part of a balanced diet [3].

Arsenic: Arsenic another dangerous and subtle heavy metal was also present in all the fish samples. Although the levels of arsenic in all the samples are very low (0.0079 - 0.015 ppm) compared with the permissible level of 0.1 ppm set by WHO/FAO, its presence in food samples has been reported to be a time bomb if not properly mitigated. According to [23], long-term exposure to arsenic from drinking-water and food substances can cause cancer and skin lesions. Arsenic has also been associated with cardiovascular disease and diabetes. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults [23]. Other researchers have reported that daily human intake of arsenic contained in food is in the range 0.5 - 1 mg, with the greatest concentrations coming from fish and crustaceans [4].

After consumption, arsenic has been reported to bind to haemoglobin, plasma proteins and leukocytes before being redistributed to other organs like the liver, kidney, lung, spleen, and intestines [4]. Most of the arsenic in marine food is in organic form and is excreted more rapidly than inorganic arsenic. Similarly, acute arsenic intoxication resulting in fatality is rare. Survivors may have severe disabilities secondary to organ damage. Chronic exposure to arsenic over weeks and months can have severe effects due to its neurotoxicity, cardiovascular and renal toxicity, and carcinogenicity [21,24].

Hazard quotient of cadmium, lead, chromium, mercury and arsenic in canned fish and some selected fish samples

A hazard quotient is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. It is primarily used to determine the health risks of toxic substances like heavy metals, pesticides, drugs etc. The result shows that the HQ was less than 1 (1) in sample numbers 11 and 14 with HQ of 1.02 and 1.16 respectively. Therefore, the risk of exposure to majority of the tested samples shows that adverse effects are not likely to occur except for samples number 11 and 14. The levels of these heavy metals in the fish samples may not pose any harm.

Conclusion

Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg) and Arsenic (As) present in canned fishes and selected fish samples in Nigeria. Heavy metals were determined using UNICAM 939 atomic absorption spectrophotometer at different wavelengths. The results shows that cadmium content was generally low in all the samples ranging from 0.0024 - 0.0099 ppm sample while the local fishes showed the highest amount ranging from 0.0074 - 0.0099 ppm. Lead content ranged from 0.017 - 0.026 ppm. The level of lead in the analyzed samples showed that the local fish samples tend to have lower lead levels while the canned fishes had higher level of lead in their tissues. The result also shows that chromium content was generally high in all the samples ranging from 0.037 - 0.058 ppm while the selected fishes show the lowest amount ranging from 0.027 - 0.031 ppm.

However, sample 14 had the highest levels of 0.058 ± 0.01 while sample 12 had the lowest level of 0.027 ppm. Mercury levels were present in some selected fishes ranging from 0.0037 - 0.0046ppm while the canned ones had mercury levels in the range of 0.0022 - 0.0039 ppm. The highest mercury level (0.0046 ± 0.01) was observed in sample 3, a locally consumed freshwater fish. The level of arsenic

in all the samples ranged from 0.0079 - 0.015 ppm. Hazard quotient result shows that the HQ was less than 1 (< 1) generally for all the samples except for Cr level that was greater than 1 (> 1) in sample numbers 11 and 14 with HQ of 1.02 and 1.16 respectively. Therefore, the risk of exposure to majority of the tested samples shows that adverse effects are not likely to occur except for samples number 11 and 14. The levels of these heavy metals in the fish samples may not pose any harm to consumers but nutrition education will help to protect against heavy metal bioaccumulation in the body.

Conflict of Interest

All authors declare that they have no conflict of interest.

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