Advances in Research
7(4): 1-6, 2016, Article no.AIR.26444
ISSN: 2348-0394, NLM ID: 101666096

SCIENCEDOMAIN *international*
www.sciencedomain.org

Levels of Zinc, Iron and Lead in Canned Fish Sold in Jos, Nigeria

Kiri H. Jaryum[1*], Samuel Y. Gazuwa[1], Samson I. Wuti[1] and Joseph Ameh[2]

[1]Department of Biochemistry, College of Medical Sciences, University of Jos, P.M.B. 2084, Jos, Nigeria.
[2]Department of Science Laboratory Technology, Faculty of Natural Science, University of Jos, P.M.B. 2084, Jos, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author JA conceived and designed the research. Authors KHJ, SYG and SIW oversaw the implementation and analytical strategy of the study. Author JA analyzed the data with statistical support from the computer centre of the University of Jos, Nigeria and wrote the draft paper. Authors JA and KHJ had primary responsibility for the final content. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AIR/2016/26444
Editor(s):
(1) Jinyong Peng, Professor, College of Pharmacy, Dalian Medical University, Dalian, China.
Reviewers:
(1) Satyavani Godavarthi, Int. Inst. of Biotech and Toxicology (IIBAT), Tamil Nadu, India.
(2) David Iordehiin Gbenyi, Federal Polytechnic Mubi, Adamawa State, Nigeria.
(3) Raquel Delvalle Salazar Lugo, Universidad de Oriente, Cumaná, Venezuela.
(4) Ilkan Ali Olgunoglu, University of Adiyaman, Turkey.
Complete Peer review History: http://sciencedomain.org/review-history/14930

Short Communication

Received 18th April 2016
Accepted 2nd June 2016
Published 7th June 2016

ABSTRACT

Introduction: Both nutritional metals such zinc and iron, and toxic metals, such as lead, present in food above certain permissible levels, pose danger to consumers. Fish harvested from contaminated waters tend to have high levels of these metals. Moreover, the level of contamination could be aggravated by processing and canning.
Aim: In this research, we determined the extent to which zinc, iron and lead are present in canned fish commonly sold in Nigerian markets.
Place and Duration of Study: This research was conducted in the Department of Science Laboratory Technology of the University of Jos, Nigeria, between the months of November, 2010 16 and May, 2011.
Materials and Methods: Canned tuna and sardine produced by different manufacturers were

*Corresponding author: E-mail: jaryumkh@gmail.com;

obtained in Jos market, Nigeria. Measurement of metal concentration in the canned fish was carried out by using atomic absorption spectrometer.
Results: The range obtained for the elements analyzed in µg/g (dry weight) in both the fish and fish oil are as follows: Zn, 22.06±0.05 - 216.67±0.52; Fe, 13.48±0.29 - 182.32±0.12; and Pb, 13.63±0.22 – 235.12±0.10.
Conclusion: The metals levels were generally above their respective FAO/WHO recommended limits. Statistical analysis showed significant difference ($p = 0.05$) between the metal concentrations in canned fish from one manufacturer and the other. We recommend that further research on metal content of canned fish sold in Nigeria be done with a view to ascertaining the level of these metals ingested by the populace.

Keywords: Canned fish; zinc; toxicity; iron; Nigeria.

1. INTRODUCTION

Canning is one of the several methods used in food processing and production, designed to prolong the shelf-life of food stuffs [1]. 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 [2]. Recently, there was a public outcry about high levels of lead in water in communities across Illinois, USA, as reported by the Chicago Tribune of Thursday, May 12, 2016. Apart from the threat from polluted environment, canned food is subjected to heavy metal contamination during the canning process [3]. Solder used in the manufacture of cans has been recognized as a source of lead contamination during canning [2]. Some metals such as zinc, copper and iron are essential to life and play vital roles in the functioning of critical enzyme systems. Other metals especially lead and mercury, are xenobiotics, and may be toxic even at trace levels of exposure [4]. Lead inhibits δ–aminolevulinate dehydratase, a key enzyme in haem biosynthesis. This causes ineffective haem synthesis and subsequent microcytic anaemia [1].

Excessive metal intake, for instance iron, however, can be toxic because free ferrous iron reacts with peroxide to produce free radicals, which are highly reactive and can damage DNA, proteins, lipids and other cellular components. This occurs when iron levels exceed the capacity of transferrin to bind the iron [5]. Humans experience iron toxicity above 20 mg of iron per kilogramme mass. The Dietary Reference Intake (DRI) lists the tolerable upper level (UL) of iron for adults 45 mg/day [6].

It is estimated that 3000 of the hundreds of thousands of proteins in human body contain zinc prosthetic groups, one type of which is the so-called zinc finger. Zinc ions are now considered to be neurotransmitters. Cells in the salivary gland, prostrate, immune systems and intestine use zinc signalling [7]. Even though zinc is an essential requirement for a healthy body, too much can be harmful. Excessive absorption of Zinc can also suppress copper and iron absorption [8-11]. Intakes of 150–450 mg of zinc per day have been associated with such chronic effects as low copper status, altered iron function, reduced immune function, and reduced levels of high-density lipoproteins [12,13]. The free zinc ion in solution is highly toxic to plant, invertebrates and even vertebrate fish [14]. The free zinc ion is also a powerful Lewis acid up to the point of being corrosive. Stomach acid contains hydrochloric acid, in which metallic zinc dissolves readily to give corrosive zinc chloride [13].

The aim of this research was to determine the concentrations of zinc (Zn), iron (Fe) and lead (Pb) in canned fish sold in Jos metropolis, Nigeria, with a view to comparing with the permissible levels.

2. MATERIALS AND METHODS

2.1 Reagents

High purity nitric acid, from the British Drug House, Poole, England; and perchloric acid, from Sigma Aldrich Labochemikalien, Germany; were used as stock solutions).

A standard digestion mixture containing nitric acid and perchloric acid in the ratio 6:1 by volume was prepared from the stock solutions [15]. Samples were digested preparatory to the spectrophotometric analysis.

2.2 Sample Collection

Canned fish of various species of Sardine and Tuna, produced in African (Ghana and Morocco)

Table 1. Samples collected

Fish type	Market name	Manufacturer
Sardine	Titus sardine in vegetable oil	UNMER, Km11 Routes de Zentas Casablanca Morocco
Sardine	Evita sardine in vegetable oil	Bali maya ppermmai desa tegal badery Negara-Bali, Indonesia
Tuna	Starkest-flake in vegetable oil	Pioneer Food Cannery Ltd. Tema, Ghana, GS/SF/EFO38
Tuna	POMO-flake Tuna in vegetable oil	The Union Manufacturing Co. Ltd., 30/2, Sethakit 1 Road, Ampler Muang, Samutsakhon, Thailand. www.watanmal.com

and Asian countries (Thailand and Indonesia) were purchased at Jos Terminus Market, Nigeria, and include those shown in Table 1 above.

The canned fish were opened and the oil drained. The drained sardine/tuna-flake were spread on a crucible/evaporating dish and dried in an oven at 60℃. The dried samples were pulverized in a ceramic mortar and pestle prior to the digestion procedure.

2.3 Digestion Procedure

One gramme of each of the samples (ground) labelled 1, 2, 3 and 4 was weighed and transferred into a 50 ml conical flask. To each of these samples, 5 ml of the standard solution was added and heated on a hot plate in a fume cupboard for 10 min. until the sample became almost dried. Another 5 ml of the ashing mixture was added and heated as above. This procedure was continued until the sample was completely burnt off leaving the inorganic (minerals) components in the form of white ash [15,16].

The drained oil of the canned fish was also ashed. Approximately 5 ml each of the sample was ashed with 5 ml of the ashing mixture in 250 ml beaker labelled 1, 2, 3 and 4, heated on the hot plate in a fume cupboard for ten (10) min. The heating process continued as more and more of the 5 ml standard digestion solution was added until white ash was obtained.

These ash samples were dissolved, each in a minimum amount of the standard digestion solution, in a 50 ml plastic bottle. Deionised water was added to the mark of the bottle. This was taken to Physical and Chemical Laboratories of the Nigeria Mining Cooperation (NMC), Jos, Nigeria, for quantitative determination of Zn, Fe, and Pb using the atomic absorption spectrophotometer (AAS), UNICAM 969. All chemicals used were of analytical grade.

2.4 Statistical Analysis

The data were analyzed using the analysis of variance (ANOVA) on the statistical software of SPSS Version 17.0, at the Academic Office of the University of Jos. The acceptable level of statistical significance for all analyses was $p < 0.05$. Results were expressed as arithmetic means±standard deviation – (SD).

3. RESULTS AND DISCUSSION

The results obtained are as shown in the Tables 2 and 3. From these tables, all values are statistically significant ($p < 0.05$). From Table 2, zinc the most concentrated in all the types of canned fish analysed, been highest in Tuna fish of Thailand. In Table 3, Zinc is still the most concentrated metal in the oils of the canned fish except in Sardine of Morocco where iron is the most concentrated.

Table 2. Average metal concentration in various canned fish (µg/g)*

Concentration of metal (µg/g)	Sardine (Morocco)	Sardine (Indonesia)	Tuna (Ghana)	Tuna (Thailand)
Zn	79.96±0.48	133.47±0.18	216.67±0.52	248.78±0.17
Fe	65.29±0.15	62.08±0.26	161.04±0.33	182.32±0.12
Pb	2.35±0.10	14.98±0.20	91.91±0.31	13.63±0.22

**Values are statistically significant (p < 0.05)*

Table 3. Average metal concentration in various canned fish oils (μg/g)*

Concentration of metal (μg/g)	Sardine (Morocco)	Sardine (Indonesia)	Tuna (Ghana)	Tuna (Thailand)
Zn	58.96±0.31	42.63±0.32	26.69±0.18	22.06±0.50
Fe	70.81±0.03	32.18±0.11	26.05±0.10	13.48±0.16
Pb	18.31±0.06	36.76±0.10	18.89±0.21	16.23±0.12

**Values are statistically significant ($p < 0.05$)*

Most marine foodstuffs are canned to be more available for the consumption by humans living away from sea site [17]. The concentration of heavy metals in canned sea food varies, depending on the type and origin of the food, pH of the product of the cans, oxygen concentration in the head space, quality of inside lacquer coating of cans, storage time, as well as humidity of storage place [17].

Zinc concentration (Table 2) in canned tuna from Thailand was significantly higher ($p < 0.05$) than Ghana. Whereas in Table 3, canned Tuna oil from Ghana had a higher concentration than that from Thailand though all of them are high. Zn is needed in the body for some biochemical processes but its overload can lead to disease conditions. There was a significant difference ($p = 0.05$) between the Zn concentration of canned sardine from Indonesia and Morocco (Tables 2 and 3). Most probable presence of Zn is attributed to the canning process, and Zn in oil implies that this metal must have leached out of the tin into the oil. The implication of ingesting very high Zn concentration range from the suppression of copper and iron absorption needed for haem biosynthesis, damage the stomach lining. The maximum zinc level permitted for fish is 5.0 mg/kg [18]. The recommended daily intakes of zinc are 15 mg for adult males and 12 mg for adult females [19]. The highest average of zinc concentration (248.78±0.17 μg/g) was found in tuna fish of Thailand, while the lowest average zinc concentration (79.16±0.48 μg/g) was found in Sardine of Morocco. This range is consistent with the findings of Celik and Oehlenschlager [20] and Mendil et al. [21] who found lowest and highest zinc levels in Turkish canned fish samples to be in the range of 33.8–566 μg/g. United States environmental protection agency and the European Commission (US-EPA and EC) have not considered any standards or limits for the zinc concentrations [22,23].

Iron concentration in Table 2 is seen to be slightly higher in canned tuna from Thailand than Ghana. Whereas in Table 3, canned tuna oil from Ghana had a concentration higher than Thailand though all the values are high. There is a significant difference ($p = 0.05$) between the canned tuna of Ghana and Thailand. Iron concentrations in both samples were found to be higher than the FAO/WHO/US-EPA permissible limits [22]. Fe is required often in animals, plants and fungi. It is incorporated into the haem complex; Haem is an essential component of cytochrome proteins which mediates redox reaction and oxygen carrier proteins such as haemoglobin and methaemoglobin. The presence of high concentration of Fe may have occurred by the corrosion of steel in the can. Fathabad et al. [24] reported iron, lead and mercury in canned fish sold in Tehran above the legal permissible limits set by health authorities. Iron overload result into disorder such as haemochromatosis, damages to the gastrointestinal tract preventing them from regulating Fe absorption, high blood concentration of Fe causes damage to the heart, liver and other tissues. There was no significant difference ($p = 0.05$) between the concentrations of iron in sardine of Indonesia and that in Morocco (Table 2). However, oils of these samples (Table 3) showed significant difference ($p = 0.05$) in their iron content. This may be for the same reason as stated above that the presence of high concentration of Fe may due to corrosion of steel in the can. Mol [25] reported iron concentrations in canned tuna fish in Turkey between 20.2–38.7 mg/kg.

From the results (Tables 2 and 3) there is a significant difference ($p = 0.05$) between lead concentration in canned Tuna of Ghana and that of Thailand. These may be as a result of the soldering processes of the tin or type of amalgam the tins are made up of. Also, the source of the tuna fish may be another source of such marked difference as fish of fresh water salt origins have different concentration of some metals. There is also significant difference ($p = 0.05$) between the concentration of lead in sardine of Indonesia and that of morocco. This may be due to the same reasons as stated for zinc above. This values are above the permissible limit set by FAO/WHO/US-

EPA [22]. Ashraf et al. [23] reported concentrations of lead in several samples of tuna fish in Saudi Arabia. The amount of lead in tuna they found were 0.002, 0.21, 0.23, and 0.84 µg /g in each sample which were less than the amount of lead in tuna in south of Iran [23,26]. Similarly, Boadi et al. [27] reported concentration of lead in canned fish marketed in Ghana in the range of 0.058–0.168 µg/g. All these results reported are lower than our findings. According to European commission [28] guideline and FAO, the allowable level of lead in fish, is 0.4 [29]. The levels of leads found in this study are more than those of the guidelines.

From literature available, there is a great variation in the metal contents of canned fish world-wide [20,21,24,30]. Canned foods, compared to other packaging approach, contain higher metal contents. Cans stored for longer period are likely to be subjected to physical damage such as corrosion and dent. As such, some of the metals may dissolve into the foods especially when the lacquer coating is damaged. Therefore, apart from the concentrations of these metals in the fish (product) itself, the container (can) can contribute greatly to the overall metal content of the canned fish, as reported in this research.

4. CONCLUSION

In this study, we found high levels of zinc, iron and lead in canned fish sold in Jos, Nigeria, at concentrations above acceptable levels. Higher metal contents were found in the fish themselves than in the fish oil; suggesting little contribution of the can itself to the total metal concentrations. We recommend that modern technology equipment with high sensitivity and precision be used in conducting research of this nature. Furthermore, research on metal content of canned fish sold in Nigeria should be done with a view to ascertaining the level of these metals ingested by the populace.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Okoye ZSC. Biochemical aspects of nutrition. Prentice-Hall of India Private Limited. 1992;147.
2. Sim SF, Devagi AK, Sung CL. Evaluation of the acid digestion with different solvent combination for the determination of iron, zinc and lead in canned sardines. Malaysian Journal of Chemistry. 2006;8(1):010-015.
3. Ikem A, Egiebor NO. Assessment of trace metal elements in canned fishes (Mackerel, tuna, salmon, sardines and herrings) marketed in Georgia and Alabama (United States of America). J. Food Composition and Analysis. 2005;18: 771-787.
4. Howard H. The Environment and Human Health; 2002.
5. Papanikolaou G. Pantopoulos K. Iron metabolism and toxicity. Toxicol Appl Pharmacol. 2005;202:199–211.
6. Food and Nutrition Board. Zinc. Dietary reference intakes for vitamin A, vitamin K, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. Food and Nutrition Board, Institute of Medicine. Washington, D.C. National Academy Press. 2002;442-501.
7. Hershfinkel M, Silveman WF, Sekler I. The zinc sensing receptor a link between zinc and cell signaling. Molmed. 2007;13(7-8): 331-336.
8. Prasad AS. Clinical spectrum of human zinc deficiency. In: Penland J, Sandstead H, Egger N, Dayal H, Alcock N, Plotkin R, Rocco C, Prasad AS, eds. Biochemistry of Zinc. New York: Plenum Press. 1993; 219-58.
9. Willis MS, Monaghan SA, Miller ML, McKenna RW, Perkins WD, Levinson BS, Bhushan V, Kroft SH. Zinc-induced copper deficiency: A report of three cases initially recognized on bone marrow examination. American Journal Clinical Pathology. 2005;123**(**1):125-131.
10. Foster MP, Petocz S, Samman S. Effects of zinc on plasma lipoprotein cholesterol concentrations in humans: A meta-analysis of randomised controlled trials. Atherosclerosis. 2010;210(2):344-352.
11. Jaryum KH, Okoye ZSC, Stoecker BJ. Copper content of staple seeds and grains grown in Kanam local government area, Nigeria. Springer Plus. 2013;2:373. Available:http://www.springerplus.com/content/2/1/373
12. Hooper PL, Visconti L, Garry PJ, Johnson GE. Zinc lowers high-density lipoprotein-

cholesterol levels. J Am Med Assoc 1980;244:1960-1.
(PubMed abstract)

13. Nriagu, Jerome. Zinc toxicity in humans. University of Michigan, School of Public Health. Elsevier B.V; 2007.
14. Muyssen BTA, Karel AC De Schamphelaere, Colin R. Janssen. Mechanisms of chronic waterborne Zn toxicity in *Daphnia magna.* Aquatic Toxicology. 2006;77:393–401.
15. Halvin JL, Soltanpour PN. A nitric acid plant tissue digestion method with ICP spectrometry for contaminate soil and plant. Anal. Chem. 1980;11:969-980.
16. Clegg MS, Keen CL, Lonnerdel B, Hurley LS. Influence of ashing techniques on the analysis of trace elements in animal tissue, I. wet-ashing. Biological Trace Elements Research. 1981;3:107:15.
17. Oduoza CF. Studies of food value and contaminants in canned foods. Food Chemistry. 1992;44(1):9-12.
DOI: 10.1016/0308-8146(92)90250-6
18. Tuzen M. Toxic and essential trace elemental contents in fish species from the Black Sea, Turkey. Food and Chemical Toxicology. 2009;47(8):1785-90.
19. Rahimi E, Mazyar Hajisalehi, Hamid Reza Kazemeini, Ali Chakeri, Amin Khodabakhsh, Mohammad Derakhshesh, et al. Analysis and determination of mercury, cadmium and lead in canned tuna fish marketed in Iran. African Journal of Biotechnology. 2010;9(31):4938-4941.
Available:http://www.academicjournals.org/AJB
20. Çelik U, Oehlenschläger J. High contents of cadmium, lead, zinc and copper in popular fishery products sold in Turkish supermarkets. Food Control. 2007;18(3):258-61.
21. Mendil D, Ünal ÖF, Tüzen M, Soylak M. Determination of trace metals in different fish species and sediments from the River Yeşilırmak in Tokat, Turkey. Food and Chemical Toxicology. 2010;48(5):1383-92.
22. Codex Alimentarius Joint FAO/WHO food standards programme. Codex Committee on methods of analysis and sampling: 19th session, Budapest, Hungary. Criteria for evaluating acceptable methods for evaluating acceptable methods for codex purposes; 1994.
23. Ashraf W. Levels of selected heavy metals in tuna fish. Arabian Journal for Science and Engineering. 2006;31(1A):89.
24. Fathabad Ayub Ebadi, Nabi Shariatifar, Ali Ehsani, Mehran Sayadi. Evaluation of toxic metals in canned fish market in Tehran. International Journal of Pharma Sciences and Research. 2015;6(5):818-822.
25. Mol S. Levels of selected trace metals in canned tuna fish produced in Turkey. Journal of Food Composition and Analysis. 2011;24(1):66-9.
26. de Mora S, Fowler SW, Wyse E, Azemard S. Distribution of heavy metals in marine bivalves, fish and coastal sediments in the Gulf and Gulf of Oman. Marine Pollution Bulletin. 2004;49(5-6):410-424.
27. Boadi NO, Twumasi SK, Badu M, Osei I. Heavy metal contamination in canned fish marketed in Ghana. American Journal of Scientific and Industrial Research. 2011; 2(6):877-882.
28. European Commission. Commission of the European Communities, Commission Regulation (EC) No. 221/2002 of 6 February 2002 amending regulation (EC) NO. 466/2002 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Communities, Brussels; 2002.
29. Sivaperumal P, Sankar TV, Viswanathan Nair PG. Heavy metal concentrations in fish, shellfish and fish products from internal markets of India vis-a-vis international standards. Food Chemistry. 2007;102(3):612-620.
30. Ergen I, Ursic S, Bosnjak K. Assessment of dietary intake of Cd, Pb, Hg via foods of the plants and animal origin in Slovenia. Med. Arh. 2002;5692):105-109.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14930