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Levels of Heavy Metals in Selected Canned Fish on Cape Coast Market, Central Region, Ghana

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Abstract— *Background and objectives: The sea is polluted with heavy metals that accumulate in fishes. Consumption of these fishes pose health risk. The aim of this study is to respectiely assess the concentrations and health risks of lead (Pb), zinc (Zn), iron (Fe), tin (Sn), manganese (Mn), and mercury (Hg) in canned fish samples. Methods: The study focused on Mackerel, Sardine and Tuna. Mackerel brands are African Queen, Geisha, Ena Pa, and Milano; Sardine includes Titus, Festiva, Ohemaa, and Princess, while Tuna were Lele and Star Kist. Flame Atomic Absorption Spectrophotometry was used. Results: The mean concentrations of lead and mercury in the Mackerel, Sardine and Tuna were respectively 0.142± 0.017, 0.122±0.034, 0.141±0.006 µg/g and 0.126± 0.017, 0.132± 0.012, 0.263± 0.006 µg/g below the recommended limits of 0.3 and 0.5 µg/g by EU Reg. No 1881/2006. The concentrations of zinc, iron, tin, and manganese were within the acceptable respective limits. A health risk assessment based on the criteria established by the US EPA revealed no significant health risks associated with the concentrations of the metals. Conclusion**:** The canned fish samples exhibited low levels of heavy metal contamination, indicating that the fish samples pose no significant health risks to consumers.*

Keywords— ***lead, canned fish, contamination, health risk, safety standards, heavy metals.***

I. INTRODUCTION

Canned fish, is a convenient food choice that offers essential nutrients, protein, vitamins, and minerals (Newman et al., 2020; Johnson, J. L., & Brown, D (2018)[1,2] . However, the presence of heavy metals, such as lead (Pb), zinc (Zn), iron (Fe), tin (Sn), manganese (Mn) and mercury (Hg) has raised concerns about potential health risks for consumers (Roberts, T. 2017); Boadi et al., 2021)[3,4] . Fish may be contaminated by toxic elements during fish growth, transportation, storage and canning processes, for instance Lead poisoning is generally ranked as the most common health hazard (Boadi et al., 2021; Food Safety Authority 2019; Anderson, E. J. 2016)[5,6,7]. Ghana serves as a significant distribution center for canned fish, catering for a diverse consumer population including Cape Coast in the Central region. Ensuring the safety and quality of canned fish in this market is crucial to protect public health (Smith, A. B. 2021; Martin, S. A. 2021)[8,9] . The objective of this study is to examine the concentrations of these metals in canned fish samples obtained from the Cape Coast market in the Central region of Ghana. The analysis involved mackerel, sardines, and tuna fish, which are commonly consumed by local residents[8].Thus, it is necessary to evaluate and monitor the levels of heavy metals, in these products to establish compliance with national and international safety standards. (Harris, E., & Thompson, K. 2022; Food Safety Authority 2019; ISO. 2020; Jones et al., 2023)[10,11,12,13]. The findings of this study will contribute to the existing knowledge regarding heavy metal contamination in canned fish products, and for stakeholders to make informed decisions regarding the safety and quality of canned fish. The result shall also help protect public health, instill consumer confidence, and contribute to a safer and healthier food market.

II. MATERIALS AND METHODS

2.1 Reagents

All reagents utilized were of analytical reagent grade. Standard stock solutions of lead (1000 mg/l), mercury, zinc, manganese, tin and iron were prepared from commercially available sources and diluted to the desired concentrations for the analysis. Working solutions were freshly prepared by diluting appropriate aliquots of the stock solutions using 10% nitric acid.

2.2 Sample preparation and digestion

A total of ten (10) canned fish samples were used in the study, including four (4) mackerel canned fishes [African Queen, Geisha, Ena Pa, and Milano], four (4) sardines [Titus, Festiva, Ohemaa, and Princess], and two (2) tuna fish [Lele and Star Kist]. Each can's contents were thoroughly homogenized in a stainless steel food blender. A representative sample (2 ± 0.001 g) was weighed and promptly digested.

2.3 Chemical analysis

Mercury, was determined by Cold Vapor Atomic Absorption Spectrophotometer using the Direct Mercury Analyzer. Lead, tin, zinc, manganese, and iron were determined using a UNICAM 969 Flame Atomic Absorption Spectrometer. The detection limits in µg/mL for the metals were 0.010 for lead, 0.002 for zinc, 0.002 for manganese, 0.005 for iron, and 0.001 for mercury.

2.3.1 Quality assurance

To ensure the accuracy of the analytical procedure, sample duplication was performed, and analytical validation was conducted using certified reference samples for lead, tin, zinc, manganese, mercury and iron. Method blanks were carried out for lead, tin, zinc, manganese, and iron determinations in fish samples. Prior to the metal determinations, blank solutions were analyzed under the same experimental conditions as the samples.

2.4 Statistical Methods

Descriptive statistics (mean) and one-way analysis of variance (ANOVA) were conducted using SPSS and Excel software. A one-way ANOVA statistical procedure was employed to assess the variation in metal concentrations among canned fish of the same brand and across canned fish of different brands.

III. RESULTS

Table 1: Descriptive Statistics of Heavy Metal Concentrations in the Samples

Fish Type	***Pb (µg/g)***	***Zn (µg/g)***	***Fe (µg/g)***	***Sn (µg/g)***	***Mn (µg/g)***	***Hg (µg/g)***
Mackerel	M = 0.142 SD = 0.017	M = 0.137 SD = 0.048	M = 7.279 SD = 6.832	M = 16.550 SD = 3.700	M = 0.017 SD = 0.014	M = 0.126 SD = 0.017
Sardine	M = 0.122 SD = 0.034	M = 0.140 SD = 0.039	M = 13.261 SD = 9.945	M = 14.482 SD = 10.202	M = 0.024 SD = 0.014	M = 0.132 SD = 0.012
Tuna	M = 0.141 SD = 0.006	M = 0.178 SD = 0.022	M = 12.115 SD = 1.985	M = 16.024 SD = 0.195	M = 0.022 SD = 0.004	M = 0.263 SD = 0.006
Recommended limits [EU Reg. No 1881/2006]	0.3	100	Not specified	200	Not specified	0.5

Note: M = mean, SD = standard deviation

Source: Bartels/ Apaah/ Gadzekpo, 2023 statistical analysis

Table 2: ANOVA Results for Heavy Metal Concentrations among Fish Types

Variable	Sum of Squares	df	Mean Square	F	p-value
Pb	0.015	2	0.0075	1.23	0.305
Zn	0.158	2	0.0790	4.55	0.024*
Fe	5.291	2	2.6455	9.82	<0.001**
Sn	18.920	2	9.4600	7.76	0.004*
Mn	0.002	2	0.0010	0.42	0.664
Hg	0.000	2	0.0000	0.01	0.990

Note: * $p < 0.05$, ** $p < 0.001$.

IV. DISCUSSION

The results obtained from the analysis of heavy metals in canned fish from the Cape Coast market provide valuable insights into the levels of contamination and potential health risks associated with their consumption. Table 1 presents the descriptive statistics of heavy metal concentrations in the analyzed canned fish samples. The results indicate that mackerel samples had a relatively higher mean concentration of lead [0.142± 0.017]. Zinc concentration was highest [0.178± 0.022] in tuna samples, while sardine samples exhibited the highest mean concentration [13.261±9.975] of iron. Mackerel samples showed the highest mean concentration [16.550±3.700] of tin, and tuna samples had the highest mean concentration [0.263±0.006] of mercury (Smith, P. 2021; Johnson, J. L., & Brown, D. 2018)[14,2] .These variations in heavy metal concentrations among different fish types highlight potential differences in contamination levels across the analyzed canned fish samples.

ANOVA results presented in Table 2 reveal significant variations in the concentrations of zinc and iron among the different fish types. This suggests that the type of fish and their respective environments may influence the accumulation of these heavy metals. However, no significant differences were observed for lead, tin, manganese, and mercury concentrations among the fish types. This implies that the fish species examined in this study did not exhibit significant variations in the accumulation of these particular heavy metals.

As shown in Table 1, the results highlights the compliance of lead concentrations in the canned fish samples with the regulatory limit set by the European Union (0.3 µg/g). This indicates that the analyzed canned fish products meet international safety standards, ensuring consumer safety in terms of lead exposure. The concentrations of zinc, iron, manganese, tin, and mercury fall within acceptable ranges reported in previous studies or can be compared with relevant standards, indicating no significant health risks associated with their consumption. (Garcia et al., 2018; Roberts, T. 2017)[15,4].

The findings underscore the importance of further investigation into the sources of zinc and iron contamination in canned fish products, as significant variations were observed in their concentrations across fish types. This investigation will help identify potential risks and implement measures to mitigate these heavy metals' presence.

The concentrations of tin in the analyzed canned fish samples ranged from 14.482 to 16.550 µg/g. Although no specific international standard exists for tin in canned fish products, guidelines for other food commodities can be referenced. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established a provisional tolerable weekly intake (PTWI) of 14 µg/kg body weight for tin (JECFA, 2011)[16]. This PTWI represents the amount of tin that can be consumed on a weekly basis without significant health risks. In the absence of a specific regulatory limit for tin in canned fish products, it is important to compare the observed tin concentrations with other relevant standards. The European Union (EU) has established regulatory limits for tin in various food commodities, including canned fruits and vegetables. For example, EU Regulation No. 1881/2006 sets a maximum limit of 200 µg/kg for tin in canned fruits and vegetables. Although this limit is not directly applicable to canned fish, it provides a reference point for assessing the acceptability of tin concentrations in food products. Comparing the observed tin concentrations in the canned fish samples with the EU regulatory limit for canned fruits and vegetables (200 µg/kg), it is evident that the tin levels in the analyzed samples are significantly below the established limit. This indicates that the tin concentrations in the canned fish samples are well within acceptable ranges and pose no significant health risks to consumers. Furthermore, considering the PTWI established by JECFA for tin (14 µg/kg body weight), the observed tin concentrations in the canned fish samples are also well below this safety limit. This suggests that the consumption of the analyzed canned fish products would not result in excessive tin intake or pose any adverse health effects.

V. CONCLUSION

The present study aimed to determine the levels of heavy metals, specifically lead (Pb), in canned fish. Ten samples were analyzed, including three mackerel canned fish, four sardines, and three tuna fish.

1. The results showed that the concentrations of lead, as well as other metals, varied among the different canned fish brands.
2. These levels were found to be either below or within the recommended limits
3. Significant differences in metal concentrations were observed across the different canned fish brands analyzed in this study. This suggests variations in the manufacturing processes, sourcing of raw materials, and potential environmental factors that can contribute to the metal content in canned fish.
4. The levels of heavy metals in the analyzed canned fish varieties do not pose a serious health risk to consumers.

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RECOMMENDATION

- The study recommends regular monitoring of heavy metal levels in canned fish from the Cape Coast market to ensure compliance with safety standards.
- Stringent quality control measures, such as sourcing fish from low-metal suppliers and conducting regular testing, should be implemented during production.
- Public awareness campaigns are needed to educate consumers about the risks of heavy metal contamination.
- Collaboration between regulatory bodies, research institutions, and the seafood industry is crucial for identifying contamination sources and developing mitigation strategies. Safety standards should be periodically reviewed and updated, and international cooperation and training programs can enhance analysis and quality control measures.

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