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Comparative Analysis of Mercury Content in Canned Versus Fresh Indian Yellowfin Tuna *Thunnus albacares*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Heavy metals are categorized into essential and non-essential types, with the latter posing significant risks to human health, particularly Mercury (Hg), a non-essential metal known for its bioaccumulative and toxic nature. *Thunnus albacares*, commonly known as Yellowfin Tuna, is a high-trophic level carnivorous fish found abundantly in the Indian Ocean, making it a subject of concern for Mercury accumulation. The present study investigates the bioaccumulation of Mercury in the muscle tissue of *T. albacares* collected from the Mumbai coast, Maharashtra. Using spectrophotometric analysis with Stannous Chloride as the reducing agent, the Mercury content was determined and compared against established safety limits. The results indicate that fresh Tuna had a slightly higher Mercury concentration (0.14 ppm) compared to canned Tuna (0.13 ppm). Both values fall within the internationally accepted safety limit for Mercury in fish (0.3–1.0 ppm

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depending on guidelines), suggesting that the tested samples are suitable for human consumption. The Mercury in Tuna comes from the environment, where it is released into the water by industrial pollution and runoff from farms. Mercury can then be absorbed by plankton, which are eaten by small fish, which are then eaten by larger fish, such as Tuna. Hence, it's the need of the hour that the release of Mercury in the aquatic ecosystem needs to be controlled.

Keywords: Bioaccumulation; canned; marine ecosystem; mercury; spectrophotometer; Thunnus albacares; toxicity.

1. INTRODUCTION

Heavy metals are classified into essential and non-essential heavy metals. Essential heavy metals are needed in small quantities by the human body to ensure their normal functioning. High quantities can become toxic and alter the normal biochemical processes of the human body's functions. Non-essential heavy metals like Mercury (Hg) are not needed by the human body and can have adverse effects on the human health (Rahmani J, et al. 2018).

Sources of Mercury can be both natural as well as anthropogenic. Natural sources that attribute to the accumulation of Mercury in nature are soil and earth's crust. Mercury can escape wastewater discharge from oil refineries in soil and water, leading to contamination of soil and water (O'Connor D, et al., 2019; Saleh T A, et al., 2020; Al-Sulaiti, M. M., et al., 2022).

Mercury bioaccumulates in the tissues of aquatic species through the ingestion of contaminated soil and food and its concentration increases through the trophic chain [Clarkson, et al., 2020]. Fish are at the top of the trophic levels in the marine ecosystem. The trophic chain starting from the bottom of the food chain to the top is as follows: heterotrophic (zooplankton and benthic invertebrates), herbivorous, and carnivorous (predatory fish). Therefore, predatory fish contain higher levels of Mercury since they are placed at the top level of the trophic chain (Karsli B et al., 2021), (Sandeep Police et al., 2021), (Wang K., et al., 2020), (Ebrahim M.A.S. Al-Ansari, et al., 2017).

Fish are generally at the top of the aquatic food chain; fish organs and tissues accumulate the heavy metals in the environment. Especially the liver, kidney, and gill organs accumulate metalloids at the highest level, and this varies according to the metal type. However, since muscle is the primary component of fish that humans eat, it is frequently examined (Sivakumar et al., 2018).

Yellow fin tuna *(Thunnus albacares)* is a commercially important pelagic fish species in the mackerel family Scombridae. It is widely distributed in tropical and subtropical regions of the Indian, Atlantic, and Pacific Oceans and plays a vital role in both ecological balance and global fisheries. Yellowfin Tuna are fast-swimming, epipelagic, oceanodromous predators capable of extensive migrations. Their streamlined bodies, large eyes, and advanced thermoregulation allow them to efficiently hunt prey such as fish, crustaceans, and cephalopods. Their position as apex predators in the marine food web makes them particularly vulnerable to Mercury accumulation (Vahabnezhad et al., 2023).

Yellowfin tuna (*Thunnus albacares*) accumulate mercury through bioaccumulation and biomagnification as they consume smaller, contaminated fish and invertebrates. As Mercury is absorbed through gills and the digestive tract, it accumulates predominantly in the muscle tissues—an area of concern since this is the main portion consumed by humans. Mercury binds strongly to proteins and lipids in Tuna muscle, resulting in high concentrations that can pose significant risks to human health, especially in vulnerable populations such as pregnant women and young children (Ordiano-Flores et al., 2011).

In addition to fresh consumption, Yellowfin Tuna is widely processed and canned, making it a convenient yet potentially hazardous dietary staple due to accumulation of mercury content and certain preservative. Despite its popularity, continuous monitoring of Mercury levels in Tuna is essential for consumer safety. While regulatory bodies have established permissible weekly intake levels for Mercury, the Mercury concentration in individual fish can vary depending on trophic level, age, size, and location of capture (Nicklisch, 2017).

Fig. 1. Yellowfin Tuna

The carnivorous fish sharp nose shark (*Rhizoprionodon oligolinx*) had the highest Mercury concentration 1.287 ppm compared to 0.0068 ppm for the Badah (*Gerres oyena*), which is considered an omnivorous fish. [Elsayed, et al. 2020]. When low or mid-trophic level species have high Mercury, the Mercury levels increase in the upper trophic level species (e.g., Tuna fish). In addition, it was reported that deeper the water column of the ocean, the higher the Mercury level in the fish species. For example, benthic species have higher Mercury levels than pelagic species (e.g., sardines and mackerels) (da Silva JM, 2020) (Maetha M. et al., 2022) A study showed that mesopelagic fish, zooplanktons, shrimps, jelly fish and snipe had lower Mercury levels compared to epipelagic fish (Al-majed N B, et al., 2020).

The literature review clearly indicates that none of the research have focused on the Mercury level of fresh and canned Tuna fish along or near the Mumbai coast. Thus, this research is relevant in this aspect. This study aims to provide a comprehensive review of the ecological characteristics, trophic position, and Mercury bioaccumulation in *Thunnus albacares*. It also discusses the implications of Mercury exposure through dietary intake of Yellowfin Tuna and highlights the need for ongoing surveillance and regulation to safeguard public health.

2. MATERIALS AND METHODS

2.1 Procurement and Preparation of the Sample

The fresh and canned Tuna were procured from the local fish market in Virar. They were brought to the Wilson College Zoology Laboratory in a small ice bucket so as to maintain the chilled condition. In the laboratory, the fish and the can were kept on ice to avoid any kind of deterioration due to temperature. The canned Tuna fish meat was obtained after opening the can, while the fresh Tuna was subjected to dressing by removing the scales, gut, head, fins, etc. The tissues were obtained by filleting, and that was used for the analysis purposes.

2.2 Chemical Analysis

The fish tissues were subjected to pretreatment before being used for the analysis. 10 grammes of fresh Tuna tissue and canned Tuna tissue were weighed. They were kept separately in different beakers and mixed with a 1:1 Dichloromethane: Methanol solution, which was later homogenised using a mortar and pestle. Accurately 3 grammes of the homogenised test samples of fresh Tuna tissue and canned Tuna tissue were taken, and then 75 ml of 4% Oxalic acid solution, 75 ml of 2% Stannous Chloride solution, and 15 ml of 1M HCl solution were added to them. The entire mixture was refluxed for 2.5 hours and kept undisturbed for around 15 minutes until the flesh completely dissolved and a froth was observed. The mixtures were then filtered through Whatman filter No. 1, and the filtered solution was diluted using 250 ml of distilled water. From this mixture, 5 ml of the final diluted solution was taken and was used for UV-Vis spectrophotometric estimation at 300 nm. The concentration was determined by comparing the O.D. of the test with that of the standard. Multiple readings were taken to eliminate the possibility of an error. This method is known as stannous chloride spectrophotometric method (J. F. Kopp et al., 1979).

3. RESULTS

The level of Mercury in the tissue of the fresh and canned Tuna after the Stannous Chloride Spectrophotometric analysis is mentioned in the table.

Table 1. Level of Mercury in the tissue of the fresh and canned Tuna

Sr. No.	Tuna type	Mercury level (ppm)
1	Canned Tuna	0.13 ± 0.005
2	Fresh Tuna	0.14 ± 0.007

4. DISCUSSION AND CONCLUSION

Various national and international organizations have established maximum permissible limits for the accumulation of heavy metals in seafood, specifically focusing on Mercury concentrations in fish. Previous studies have identified these threshold values and the safety limits for consuming seafood based on heavy metal content. The results of this study highlight the concentration of Mercury in both canned and fresh Yellowfin Tuna and compare their differences (Scutarașu et al*.,* 2023).

The results indicate that fresh Tuna had a slightly higher Mercury concentration (0.14 ppm) compared to canned Tuna (0.13 ppm). Both values fall within the internationally accepted safety limit for Mercury in fish (0.3–1.0 ppm depending on guidelines), suggesting that the tested samples are suitable for human consumption. However, the slight difference in concentration may be attributed to various factors such as processing, storage conditions, and regional environmental exposure prior to harvesting (Gerstenberger, et al*.,* 2010).

The fresh Tuna are consumed more as the result of their accessibility and relative reasonable price by the local population. The Mercury in Tuna comes from the environment, where it is released into the water by industrial pollution and runoff from farms. Mercury can then be absorbed by plankton, which are eaten by small fish, which are then eaten by larger fish, such as Tuna (Risher, John F., et al. 2002; Rasmussen, Rosalee S., et al*.,* 2005; Palathoti Suvarna Raju, 2022; Rahman, Zeeshanur and Ved Pal Singh, 2019).

As the Mercury moves up the food chain, it becomes more concentrated. Hence the concentration of Mercury in the environment needs to be controlled and at the same time serving of Tuna per week also needs to be restricted. Mercury exposure is also associated with increased risk of hypertension, myocardial infarction, coronary dysfunction, and atherosclerosis. Mercury exposure was linked with the progression of atherosclerosis and an increased risk of developing cardiovascular disease. Mercury levels are predictors of the levels of oxidized low-density lipoprotein (LDL) oxidized LDL particles are frequently found in atherosclerotic lesions and are associated with the development of atherosclerotic diseases and acute coronary insufficiency. In pregnant women, it can cross the placenta and affect the developing foetus, leading to significant and lasting developmental effects. Children are particularly vulnerable to Mercury's harmful impacts due to their rapid growth and development. In foetuses, exposure can impair brain formation, leading to cognitive and neurological defects. Studies have shown that prenatal exposure to Mercury is linked to decreased IQ, learning difficulties, and delayed language development in children. Mercury's neurotoxic effects are most pronounced during critical stages of brain development, such as neuron differentiation, migration, and synaptic pruning (Nabi Shabnum, 2014; World Health Organization, 1989, 2010, 1976). Hence it's the need of the hour that the release of Mercury in the aquatic ecosystem needs to be controlled.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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