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Assessment of heavy metal concentration in arothron stellatus from Tharuvaikulam fish landing (Thoothukudi district, Tamil Nadu): a food safety concern for local fisherman

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ABSTRACT: Heavy metals pose a significant threat to fish and human health, causing bioaccumulation and biomagnification in marine food chains. The starry puffer fish *Arothron stellatus*, commonly caught by local fishermen in Thoothukudi district, is consumed only in its muscle tissue due to the presence of the toxic compound tetrodotoxin. This study investigated the heavy metal accumulation in *Arothron stellatus* muscle tissue, revealing elevated levels of lead (7.24 mg/kg), cadmium (0.23 mg/kg), and copper (4.45 mg/kg). Zinc, an essential element, was also detected but is not a concern due to its non-toxic nature. Lead concentrations surpass safe limits, while cadmium levels teeter on the brink of danger. The presence of lead and cadmium, however, raises health concerns for consumers, highlighting the need for regular monitoring of heavy metal levels in marine species. This study sounds a warning bell for food safety and highlights the urgent need for vigilant monitoring and consumer education to mitigate the risks associated with consuming this potentially poisonous fish.

Keywords - Heavy metals, puffer fish, Bioaccumulation, Atomic spectrophotometry

Introduction

The concern over the nutritional worth of seafood has led to a rise in intake worldwide (Velusamy *et al*., 2014)[2]. Fish is an important source of high-quality protein, polyunsaturated fatty acids (PUFA), vitamin B, and minerals. However, when industry develops rapidly, environmental pollution becomes increasingly significant in some coastal and estuary areas. Marine creatures can collect these pollutants in muscular tissues, posing a health concern. Heavy metals are thought to pose a significant global environmental issue (Wang *et al*, 2018)[1]. The contamination of aquatic environments with heavy metals comes from both natural and man-made sources. The heavy metal contaminants from man-made sources are dumped directly into the coastal environment, where they are converted into bioavailable form and accumulate in marine organisms (Velusamy *et al*., 2014)[2]. Marine species absorb harmful heavy metals from the marine environment, which are then biologically amplified via the trophic levels of the food chain. The ingestion of aquatic organisms presents a serious health risk to the global human population (Anandkumar *et al*., 2020; Arulkumar *et al*, 2017)[3,4]. Fish can be utilized as an outstanding bioindicator to investigate the heavy metal concentration in water bodies (Rajaram *et al*., 2020)[5]. Moreover, trophic level, eating habits, age, sex, length of metal exposure, season, distribution, habitat preferences, and the activity of the homeostatic regulatory system all influence the amount of metal that accumulates in marine organism (Anandkumar *et al*., 2020; Sankar *et al*., 2006)[3,6]. Puffer fishes have been known to cause fish poisoning since ancient times. It is arguably the most prevalent fish poisoning along Asia's coastlines (Hwang *et al*., 2002)[7]. Puffer fish are considered the second most venomous animal in the world. The puffer fish gets its name from puffing out water or air when threatened by predators, giving it a balloon-like appearance. The puffer fish is known by numerous names around the world, including blowfish, toadfish, swellfish, globe fish, bubble fish, balloon fish, and sea squab (Torda *et al*., 2002)[8]. Metals are of particular importance among contaminants that may build up in fish since studies have indicated that they may cause oxidative stress and hinder fish growth. Because heavy metals can accumulate, their presence in aquatic ecosystems can have a stressful effect on biota (Oncel *et al*., 2000)[9]. Non-essential metals can accumulate in fish organs, while essential metals are required for optimal metabolism (Canli and Atli 2003)[10]. Essential metals include Fe, Cu, Zn and manganese (Mn), whereas non-essential metals are Hg, Pb, nickel (Ni) and Cd (Türkmen *et al*., 2005)[11]. The harmful effect of trace elements when consumed above the recommended limit can be toxic (acute, chronic or sub-chronic), and heavy metals can be neurotoxic, carcinogenic, mutagenic or teratogenic. Tetrodotoxin (TTX), one of the strongest neurotoxins, is present in puffer fish (Lago *et al*., 2015)[12]. This species is also recognized for its toxicity due to the presence of tetrodotoxin, making it unfit for consumption by the general public. Despite its toxicity, local fishermen may consume the muscle tissue of *Arothron stellatus*, raising concerns about potential heavy metal accumulation in these tissues. This study aimed to assess the concentration of copper, zinc, lead and cadmium in the tissues of the fish collected from the Tharuvaikulam fish landing site of Thoothukudi district. The results were then compared to permissible limit from the World Health Organization (WHO) and Food and Agricultural Organization (FAO) to detect whether the heavy metal contamination levels in the fish of Gulf of Mannar exceeds the safe consumption permissible limit.

METERIALS AND METHODS

Systematic position of experimental animal

Kingdom : Animalia
Phylum : Chordata
Sub phylum : Vertebrata
Class : Actinoptergii
Order : Tetraodantiformes
Family : Tetraodanitidae
Genus : *Arothron*
Species : *stellatus*

Description of study site

The study area, Tharuvaikulam fish landing centre, is located in the coastal village of Tharuvaikulam, Thoothukudi District, Tamil Nadu, India (latitude: 8.75°N, longitude: 78.12°E). The site is situated on the southeastern coast of India, approximately 10 km south of Thoothukudi town. The fish landing site receives a wide variety of fish species, including *A. stellatus*, which is commonly caught by local fishermen. The area's proximity to the Gulf of Mannar and the Palk Strait makes it an important location for marine biodiversity and fisheries research.

Collection of fish sample

The selected starry puffer fish *Arothron stellatus* of Tharuvaikulam fish landing centre, Thoothukudi district, Tamil Nadu were caught by local fishermen using gill net of various sizes. The fish species washed with sea water, then ice- packed and transported to the laboratory and identified with the help of fishes of India (Day, 1978).

Fish tissue preparation and analysis of heavy metals

Muscle tissue of fish was used in this study because it is the major target tissue for metal storage. Fish tissues were cut and oven dried at 110º C to a constant weight. The dried tissue was grinded into powder by a heavy duty blender. Then the powder was placed into digestion flask and ultrapure concentrated nitric acid and hydrogen peroxide [1: I V/V] [SD fine chemicals] were added. The digestion flask was heated to 130 °C until all the material was dissolved. Digest was diluted with double distilled water appropriately (Yilmaz, 2003). The elements like cadmium, copper, lead and zinc were assayed using ELICO's SL-176 Double Beam Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The determination of metal concentration in the muscle tissue of *Arothron stellatus* was presented in Table1. The distribution of heavy metals in fish tissue analyzed were in the order of magnitude as Zinc> Lead> Copper> Cadmium.

The bioaccumulation of metal concentration in the starry puffer fish *Arothron stellatus* are presented in Figure 1. In muscle tissue they were Zn 33.27± 0.02, Pb 7.24± 0.03, Cu 4.45± 0.02 Cd 0.23± 0.02 mg/ Kg dry weight. The elevated concentration found in muscle tissue is Zinc 33.27±0.02, while the least concentration is cadmium 0.23±0.02. According to FSSAI (Food Safety and Standards Authority of India), FAO (Food and Agriculture Organization) and WHO (World Health Organization) among these four metals, Pb level (7.24mg/ Kg) exceeds the permissible limit of 1.0mg/ Kg, which may indicate contamination. In my study, Cadmium level in the tissue of A. stellatus were found to be 0.22mg/ Kg, approaching the permissible limit of 0.3mg/ Kg set by FSSAI/FAO/WHO guidelines. This suggests that the cadmium contamination in the sample is near the threshold level, warranting close monitoring to ensure food safety. Fish liver and kidney accumulated considerable amounts of all metals, whereas muscle accumulated significantly less. The fish kidney, which detoxifies metals, has accumulated considerable levels of heavy metals (Vinodhini and Narayanan, 2008)[13]. Previous studies indicate the content of Pb fluctuates between 0.07 and 0.45ppm. The industrial region fishes had a high Pb content compared to fish from non-industrial sites and canned sea foods due to fly ash which spread all over the site from Thermal power station (Sathish *et al*., 2010)[14]. Similar results were reported by Kaleshkumar Karunanidhi *et al*., (2017)[15] who conducted the first study on the distribution of heavy metals and proximate analysis in marine edible puffer fish in South India. The average Pb concentration in all the fishes was around 8.31 mg/kg, which was several orders higher than the allowable level advised for human consumption according to the FAO (Food and Agriculture Organization) and WHO (World Health Organization). He also stated that the mean Cd concentration (0.24 mg/kg) was higher than the FAO's critical limit for human consumption (Kaleshkumar Karunanidhi *et al*., 2017)[15]. The Gulf of Mannar region has lately been affected by heavy metals from numerous industrial activity along the Arumuganeri, Tuticorin, and Mandapam coasts. Thus, Chloralkali facilities, Sterlite copper, thermal power plants, and pulp and paper manufacturing units produce significant quantities of heavy metal-containing effluents in the southern portion of the Gulf of Mannar (Palanichamy and Rajendran, 2000)[16].

Table 1: Mean concentration of heavy metals in *Arothron stellatus* from the Tharuvaikulam fish landing site during (March 2023) and the permissible limit in fish.

S. No	Elements	Concentration in mg/ Kg (Mean± Standard deviation)	Permissible limits (mg/ Kg) FSSAI/ FAO/ WHO
1.	Copper	4.45± 0.02	10-15
2.	Cadmium	0.23± 0.02	0.1-0.3

3.	Zinc	33.27± 0.02	50
4.	Lead	7.24± 0.03	1

FSSAI - Food Safety and Standards Authority of India, FAO- Food and Agriculture Organization, WHO- World Health Organization

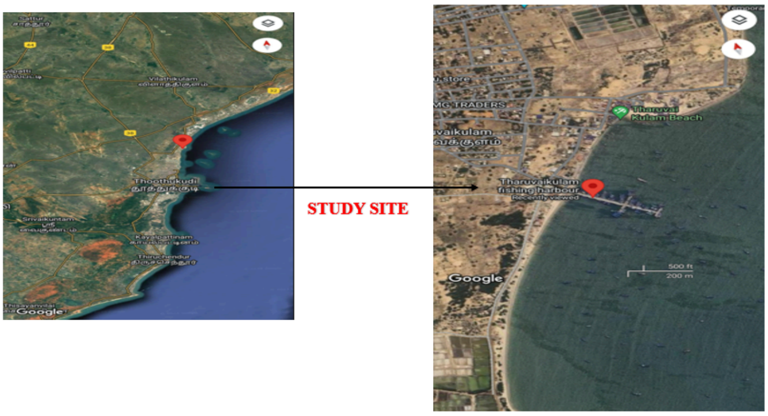

Figure 1: Tharuvaikulam fish landing from Gulf of Mannar Marine Biosphere Reserve, South India.

Figure 2: Plate showing Starry puffer fish *Arothron stellatus*

CONCLUSION

This study investigated the levels of heavy metals (copper, cadmium, zinc, and lead) in starry puffer fish (*Arothron stellatus*). The results showed that lead levels exceeded the permissible limit, while cadmium levels were near the threshold. These findings suggest potential health risks for consumers, particularly local fishermen who consume the muscle tissue. Regular monitoring and awareness programs are recommended to ensure food safety and mitigate the risks associated with heavy metal contamination in this species.

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