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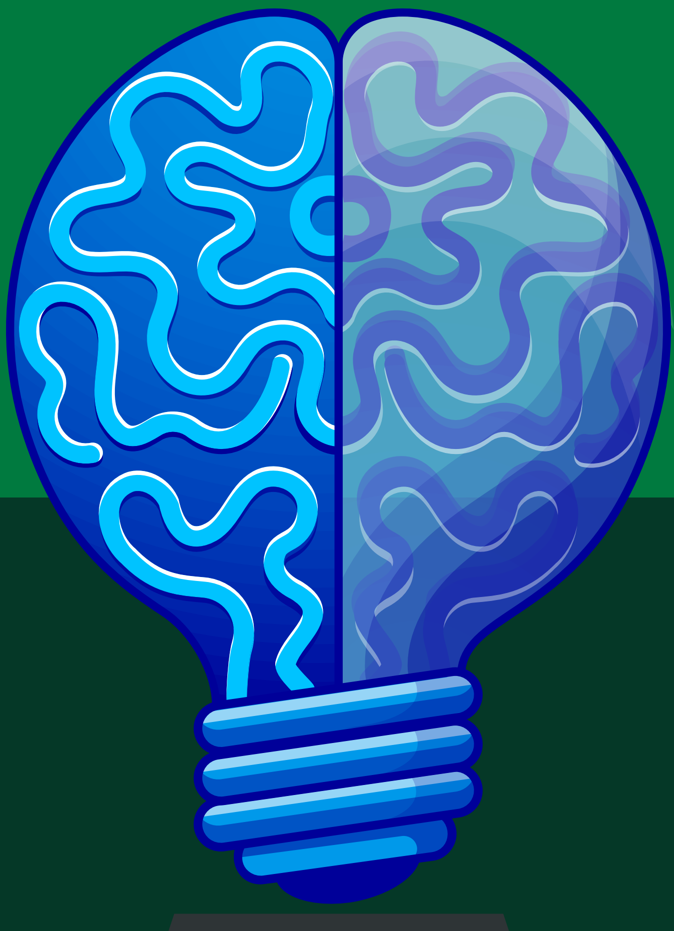

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Preface

The Scientific Project Colloquium offers a platform for publishing Diploma Science final year projects (FYP). The objective is to effectively distribute research findings throughout all scientific disciplines. The primary objective of including final year projects into the course curriculum is to encourage students to put their theoretical knowledge into practical applications.

We would like to express our gratitude to our primary establishment, the Faculty of Applied Sciences and Universiti Teknologi MARA, Perak Branch, for their invaluable assistance.

Lastly, we would like to express our gratitude to all of the authors for the tremendous help in preparing the articles, without which this undertaking would not have been completed.

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ASSESSMENT OF HEAVY METAL CONTENTS IN ANCHOVIES USING ATOMIC ABSORPTION SPECTROSCOPY

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Abstract: This study was designed to assess the concentration of iron (Fe) and cadmium (Cd) in anchovies by using Atomic Absorption Spectroscopy (AAS) across four different shops (TF Mart, Segi Fresh, 100 Mart and Pasar Mini Tapah) around Tapah, Perak. This research also aims to assess the potential health risks of these metals by calculating the Hazard Index (HI) values. Sample preparation involved drying the anchovies in an oven at 60°C and then grinding them into a fine powder, which was sieved for uniformity. The digestion process was carried out by mixing the samples with 6 mL of 65% nitric acid (HNO_3) and 4 mL of 37% hydrochloric acid (HCl) to create a homogenized solution. Following digestion, the samples were diluted to a final volume of 100mL using a volumetric flask and filtered twice by using gravity filtration and microfiltration to remove any undigested particles for smooth analysis with AAS. The results of Fe contents in anchovies are 4.22 ppm (TF Mart), 5.16 ppm (Segi Fresh), 5.88 ppm (Pasar Mini Tapah) and 6.72 ppm (100 Mart) respectively. Meanwhile, for Cd the results are 0.06 ppm (TF Mart), 0.15 ppm (Segi Fresh), 0.15 ppm (Pasar Mini Tapah) and 0.41 ppm (100 Mart), respectively. The analysis shows that all HI values are below 1, indicating no significant health risks.

Keywords: Heavy metal pollution, Cadmium (Cd), Iron (Fe), Atomic absorption spectroscopy (AAS), Hazard index (HI)

INTRODUCTION

Heavy metal pollution in aquatic environments is a significant concern due to industrial discharges, agricultural runoff, and urbanization. This pollution introduces harmful contaminants that adversely affect marine ecosystems and human health. One major issue associated with heavy metal pollution is bioaccumulation which occurs when these metals are absorbed by marine organisms at a faster rate than they can be metabolized or excreted. This accumulation, particularly in commercially important species like anchovies, poses risks to marine life and humans who consume contaminated seafood (Manev et al., 2021). Cd and Fe are of particular interest due to their toxicological implications and prevalence in marine environments. Cd is known for its high toxicity, even at low concentrations, and can cause severe health effects on marine species and humans. Cd primarily enters organisms through ingestion and inhalation (Ismail et al., 2018). Meanwhile, Fe, although essential for biological processes, can become harmful when present in excessive amounts, disrupting the delicate balance of aquatic ecosystems.

Despite advancements in research on heavy metal concentrations in marine organisms, significant gaps persist in understanding Cd and Fe levels in anchovies. Although various studies employing Atomic Absorption Spectroscopy (AAS) have documented heavy metal levels in fish tissues, comprehensive data on Cd and Fe concentrations in anchovies from Malaysia remain limited (Bat et al., 2014; Galaţchi et al., 2017). Furthermore, the Hazard Index (HI), a key measure of seafood safety based on heavy metal content, has not been thoroughly explored in anchovies from this region. These gaps hinder a complete understanding of the ecological and public health risks posed by heavy metal contamination through seafood consumption.

The objectives of this study are to determine the concentrations of Cd and Fe in anchovies using AAS and to assess the health risks associated with these metals by calculating their HI values. These anchovies are sourced from suppliers based in Pangkor Island, ensuring they represent the local fishing practices of the region. This study provides valuable insights into the assessment of heavy metal contamination in anchovies, contributing to the evaluation of environmental pollution and its implications on seafood safety. This research also underscores the importance of regular monitoring and regulatory measures to ensure anchovy products comply with safety standards.

METHODOLOGY

Sample Preparation

Random sampling was employed to select anchovy samples from four shops, ensuring coverage of major regions known for high anchovy distribution. Approximately 100 grams of anchovies were collected from each shop using a systematic random sampling method. The samples were dried in an oven at 60°C until a constant weight was achieved. Once dried, they were ground into a fine, uniform powder using a laboratory blender to homogenize the sample and ensure consistency across analyses. Finally, the ground samples were sieved to achieve a consistent particle size for accurate digestion.

Digestion Procedure & AAS Analysis

Approximately 1 g of ground anchovy sample was weighed into labelled beakers. In a fume hood, 6 mL of 65% HNO_3 and 4 mL of 37% HCl were added to each beaker. The samples were then heated on a hot plate (80–100°C) until the solution became clear. After cooling, each solution was transferred into a 100 mL volumetric flask and diluted to the mark with 1% HNO_3. The diluted solutions were first filtered by gravity, followed by microfiltration for further purification. The final filtrates were analysed using Atomic Absorption Spectroscopy (AAS) (PerkinElmer Analyst 400) to determine the concentration of Fe and Cd.

Data Analysis

The HI values for each shop can be determined based on the concentrations obtained from the AAS analysis. These concentrations are converted to mg/kg to calculate the Target Hazard Quotient (THQ) values. THQ is a number used to estimate the possible health risks of being exposed to a harmful substance, like heavy metals, from a certain source. It's often used to assess the risk of non-carcinogenic effects caused by contaminants found in food, water, or air. The formula to calculate THQ is:

$$THQ = (EF \times ED \times MS \times C / RfD \times BW \times AT) \times 10^{-3}$$

EF stands for exposure frequency, which is 365 days/year. ED is the exposure duration. The exposure duration is determined based on the average lifespan of Malaysians, which is approximately 70 years. MS represents the food ingestion rate, with Malaysians consuming fish daily at an average of 0.122 kg per day (Von Goh et al., 2021). C stands for concentration in mg/kg. RfD refers to the reference dose values for Fe and Cd, set at 0.70 mg/kg/day for Fe and 0.001 mg/kg/day for Cd, respectively (Karsli, 2021). BW stands for body weight, with Malaysians' average body weight is 62.65kg (Azmi, M. Y. et al., 2009). AT represents the average exposure time, calculated as 70 years (the average lifespan of Malaysians) multiplied by 365 days (the exposure frequency) (Pokorska-Niewiada et al., 2022).

HI is calculated to assess whether the anchovies from each shop are safe for consumption. The formula of HI is:

$$HI = THQ_{Fe} + THQ_{Cd}$$

This calculation is performed individually for each shop to assess the combined exposure to Fe and Cd from the anchovies available, ensuring a detailed and location-specific evaluation of potential risks.

FINDINGS

Table 1 presents the concentration levels of Fe and Cd along with their respective THQ and HI values, for anchovy samples obtained from four different shops. Concentration of Fe ranged between 4.22 mg/L (TF Mart) and 6.72 mg/L (100 Mart), with values converted to mg/kg ranging from 4033.26 mg/kg to 6617.43 mg/kg. Meanwhile, Cd concentrations were lower, ranging from 0.06 mg/L (TF Mart) to 0.41 mg/L (100 Mart), with corresponding values in mg/kg ranging from 57.34 mg/kg to 403.74 mg/kg.

Table 1 Concentration, THQ and HI values for Fe and Cd in anchovies across four different shops

Source	Iron (Fe)			Cadmium (Cd)			HI
	Conc. (mg/L)	Conc. (mg/kg)	THQ	Conc. (mg/L)	Conc. (mg/kg)	THQ	
TF Mart	4.22	4033.26	0.01	0.06	57.34	0.11	0.12
Segi Fresh	5.16	4795.98	0.01	0.15	139.42	0.27	0.28
Pasar Mini Tapah	5.88	5524.24	0.02	0.15	140.92	0.27	0.29
100 Mart	6.72	6617.43	0.02	0.41	403.74	0.79	0.81

The calculated THQ values for Fe were consistently below 0.02, indicating minimal health risks. For Cd, the THQ was highest at 0.79 (100 Mart) but remained within acceptable safety limits. The combined HI values, representing the cumulative risk of Fe and Cd, remained below the critical threshold of 1 for all locations. The highest HI of 0.81 was recorded at 100 Mart, confirming that the anchovies were safe for consumption but underscoring the need for ongoing monitoring.

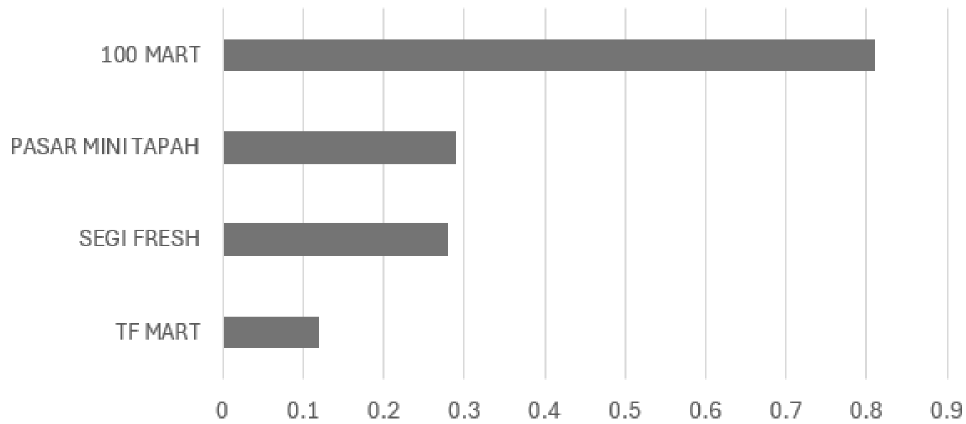

Figure 1 HI values for anchovies in four different retail shops

The significant difference in HI values for anchovies from 100 Mart compared to other shops, despite all sources originating from Pulau Pangkor, suggests various possible factors influencing the contamination levels. One plausible explanation is post-harvest handling and storage practices. While the anchovies may be caught in the same waters, the way they are handled after being brought to shore can vary significantly between suppliers. Exposure to contaminated packaging materials or metal-based preservation techniques during storage at 100 Mart could have contributed to the higher cadmium concentration (Ahmed et al., 2020).

Another factor could be environmental or processing contamination. Even if all anchovies come from Pulau Pangkor, differences in drying methods or equipment used during processing could inadvertently introduce additional contaminants. For instance, using processing tools with metal components or operating in environments with exposure to pollutants may increase the cadmium levels in the anchovies supplied to 100 Mart (Wu et al., 2019).

Batch variability is also a likely contributor. Differences in harvesting times and specific fishing zones within Pulau Pangkor waters may result in variability in heavy metal accumulation. The batch supplied to 100 Mart may have come from an area with higher cadmium exposure due to localized contamination, possibly from industrial or agricultural runoff (Rahman et al., 2021).

Additionally, analytical or sampling inconsistencies might have influenced the results. Sampling methods that did not fully represent the overall stock at 100 Mart or cross-contamination during testing could lead to inflated cadmium levels. This highlights the importance of robust and standardized testing protocols to ensure reliable data (Zhang et al., 2020).

Finally, packaging materials may have played a role. If 100 Mart used non-food-grade packaging, metal leaching could occur, particularly in high-humidity or temperature environments, further elevating the cadmium content in the anchovies. These findings underscore the importance of investigating the entire supply chain, from post-harvest handling to packaging and distribution, to ensure consistent seafood safety even when sourced from the same location.

Overall, the study concludes that anchovies from the analyzed locations do not pose significant health risks based on the measured concentrations of Fe and Cd. However, continued monitoring and stricter environmental controls are recommended to address heavy metal pollution and ensure seafood safety. These findings contribute to the understanding of heavy metal bioaccumulation in anchovies and its implications for public health and environmental conservation.

CONCLUSION

In conclusion, this study successfully determined the concentrations of Fe and Cd in anchovies from four shops in Tapah, Perak, using AAS. The results showed that all HI values were below the safety threshold of 1, indicating no significant health risks associated with the consumption of these anchovies. The highest HI value of 0.81 was recorded at 100 Mart, which is still within safe limits, highlighting the need for continuous monitoring. These findings confirm the study's objective of evaluating the safety of anchovies based on their heavy metal content and provide a clearer understanding of their quality and potential health impacts.

The findings underscore the importance of ensuring seafood safety and contribute to a deeper understanding of metal contamination in aquatic ecosystems. Future recommendations include broadening the scope of metal analysis, refining sampling strategies, and strengthening environmental policies to minimize contamination risks.

COMPLIANCE OF ETHICAL STANDARD

This study followed strict ethical and professional guidelines. All protocols were established to ensure the study's transparency, neutrality, and integrity. The funding sources for this study have been reported, and no potential conflicts of interest, financial or otherwise, have been detected. Ethical considerations for animal welfare were closely monitored, ensuring that the anchovies utilised in this study were sourced ethically and treated in accordance with recognised protocols. Any human involvement in sample collection or handling required informed consent, and participant privacy was protected. These indicators demonstrate a commitment to upholding high ethical standards throughout the study process.

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