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Physicochemical analysis of fishes sold in wet market in Tuguegarao City, Cagayan, Philippines

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Abstract

Fish is a vital component of a healthy diet, providing essential nutrients such as calcium, phosphorus, iron, zinc, iodine, magnesium, potassium, proteins, and vitamins. These nutrients contribute to lowering blood pressure and reducing the risk of heart attacks. In the Philippines, fish is the second staple food after rice, with significant per capita consumption driving an increase in fish farming. This study investigates the physicochemical properties of fish sold in Tuguegarao City's wet markets, focusing on heavy metal contamination by lead (Pb) and cadmium (Cd). Samples from common fish species-Bangus, Galunggong, Tilapia, and Hito—were collected and analyzed. The study found variations in fish length, weight, and pH, with Tilapia and Hito showing optimal freshness and quality. Heavy metal analysis revealed that all samples contained Pb and Cd levels below the permissible limits set by regulatory authorities, indicating they are safe for consumption. However, continuous monitoring is essential to ensure long-term safety and quality. The findings underscore the need for stringent handling practices and ongoing evaluation to safeguard public health against potential contaminants in fish products.

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Introduction

Fish is a critical component of global diets, providing essential nutrients such as calcium, phosphorus, iron, zinc, iodine, magnesium, potassium, proteins, and vitamins. These nutrients are vital for maintaining health, lowering blood pressure, and reducing the risk of heart attacks. As one of the healthiest foods, fish plays a crucial role in global food security and nutrition strategies, contributing significantly to the eradication of hunger and malnutrition.

Despite the well-documented benefits of fish consumption, there are significant gaps in ensuring the safety and quality of fish sold in wet markets. Wet markets, characterized by their open-air setups and variable storage conditions, pose unique challenges in maintaining fish freshness and preventing contamination. These markets are prevalent in many developing countries, including the Philippines, where fish is the second staple food after rice. With the increasing demand for fish, there is a corresponding rise in fish farming, which introduces additional variables that can affect fish quality.

Physicochemical analysis of fish is essential to address these gaps, particularly in assessing the freshness and quality of fish sold in wet markets. Freshness indicators, such as physical appearance, texture, and pH, are critical for determining the suitability of fish for consumption. Moreover, the accumulation of heavy metals, specifically lead (Pb) and cadmium (Cd), poses a significant health risk. These contaminants can accumulate in fish tissues and, when consumed, can lead to severe health issues, including neurological and renal problems.

This study aims to conduct a comprehensive physicochemical analysis of fish sold in the wet markets of Tuguegarao City, Cagayan. By determining the levels of heavy metals, specifically Pb and Cd, and assessing the freshness and quality of fish, this research seeks to fill critical gaps in food safety and provide valuable insights for consumers, vendors, and regulatory bodies. The ultimate purpose is to ensure that the fish available in these markets are safe and of high quality, thereby protecting public health and supporting sustainable fish consumption.

Materials and methods

Study design

This study adopts an observational and analytical approach to assess the physicochemical properties and heavy metal contamination of fish sold in wet markets in Tuguegarao City, Cagayan. The study involves the collection, handling, and analysis of fish samples to determine their freshness, quality, and levels of lead (Pb) and cadmium (Cd).

Data gathering procedure

Sample collection

Fish samples were collected from the Fish Depot in Tuguegarao City. Four common fish species-Tilapia, Bangus, Hito, and Galunggong—were selected. Five samples of each species were obtained from different stalls to ensure variability and representativeness. The samples were collected, individually wrapped in aluminum foil, labeled, and transported on ice to the Central Analytical Laboratory for analysis.

Sample handling

Upon arrival at the laboratory, the fish samples were stored in freezers at -18 degrees Celsius until analysis. Chain-of-custody procedures were followed to maintain the integrity of the samples. Before analysis, the samples were thawed, thoroughly washed, and homogenized to ensure uniformity in the testing process.

Physical analysis

The length and weight of each fish sample were recorded. Length measurements included standard length, fork length, and total length. Weight was measured using a calibrated digital scale. These measurements provided baseline data on the size and growth patterns of the fish.

Sensory characteristics such as skin appearance, eye clarity, gill color, and odor were evaluated using the Quality Index Method (QIM). Each parameter was scored, and the total score was used to assess the freshness of the fish.

The pH of the fish meat was measured using a digital pH meter. pH values provide insight into the freshness and potential spoilage of the fish samples.

Chemical analysis

The fish samples were analyzed for lead (Pb) and cadmium (Cd) content. Dry tissue samples (0.2 g each) were digested using a mixture of nitric acid and perchloric acid. The digested samples were then diluted, filtered, and analyzed using flame atomic absorption spectrophotometry. Results were expressed in parts per million (ppm) on a dry weight basis.

Data analysis

Data were analyzed using descriptive statistics. The concentrations of Pb and Cd were compared to established food safety standards to determine compliance. The Quality Index scores and pH values were also analyzed to evaluate the freshness and quality of the fish samples.

Results and discussion

Length and weight of fish samples

A total of 20 fish samples comprising of 4 species (Bangus, Galunggong, Tilapia and Hito) were collected during the duration of the sampling period. Five (5) samples per fish species were collected, one sample from each of the fish stalls at the Tuguegarao City Fish Depot. The measurements of length and weight are summarized in Table 1.

The average total length of Bangus samples was 40.2 cm, ranging from 32 to 46.5 cm. Galunggong samples had an average total length of 21.6 cm, ranging from 17 to 25.5 cm. Tilapia samples averaged 22.7 cm, while Hito samples averaged 37.16 cm. The average weight of Bangus samples ranged from 311 to 855 g, with an average of 624.6 g, which is higher than the 550 g recorded by BFAR (2022) in The Philippine Milkfish Industry Roadmap (2021-2040). Galunggong samples averaged 117 g, Tilapia samples weighed an average of 268.2 g, and Hito samples averaged 348.4 g.

The differences in length and weight among the species reflect their growth patterns, influenced by factors such as environmental conditions, food availability, and genetic traits (Fontoura *et al.*, 2010). Larger sizes in Bangus and Hito may indicate better growth conditions or genetic superiority. The lower weight of Galunggong compared to reported standards suggests either suboptimal growth conditions or younger fish samples.

Table 1. Length and weight of fish samples

Fish	Sample	Weight (g)	Ave	Length (cm)			Ave
				Standard	Fork	Total	
	CB1	707		32.5	40.5	41.5	
	CB2	311		31	24.5	32	
Bangus	CB3	848	624.6	44	35.5	46.5	40.2
	CB4	402		34.5	27.5	35.5	
	CB5	855		44.5	34.5	45.5	
	CG1	121		20	21	22.5	
	CG2	99		19.5	20	21.5	
Galunggong	CG3	115	117	19	20.5	21.5	21.6
	CG4	59		15	16	17	
	CG5	191		22.5	24	25.5	
	CT1	375		20	21.5	24	
	CT2	269		19.5	21.5	24	
Tilapia	CT3	228	268.2	17.5	19.5	21.5	22.7
	CT4	267		19	20.5	23	
	CT5	202		16.5	20.5	21	
	CH1	309		31.5	35.5	36	
	CH2	357		32.8	35.5	37.5	
Hito	CH3	398	348.4	32.3	35.5	37.5	37.16
	CH4	454		36.5	39	40.8	
	CH5	224		29.5	32	34	

Table 2. Quality assessment of fish samples

Sample	General appearance				Eyes		Gills		Total
	Skin	Bloodspot on gill	Belly	Smell	Clarity	Shape	Color	Smell	
CB1	0	0	0	0	0	0	0	0	0
CB2	0	0	0	0	0	0	0	0	0
CB3	0	0	0	0	0	0	0	0	0
CB4	0	0	0	0	0	0	0	0	0
CB5	0	0	0	0	0	0	0	0	0
CG1	1	1	1	0	0	0	1	0	4
CG2	1	1	1	1	0	0	1	1	6
CG3	1	1	2	2	1	2	1	1	11
CG4	1	1	1	1	0	0	1	0	5
CG5	1	1	1	0	0	0	1	0	4
CT1	0	0	0	0	0	0	0	0	0
CT2	0	0	0	0	0	0	0	0	0
CT3	0	0	0	0	0	0	0	0	0
CT4	0	0	0	0	0	0	0	0	0
CT5	0	0	0	0	0	0	0	0	0
CH1	0	0	0	0	0	0	0	0	0
CH2	0	0	0	0	0	0	0	0	0
CH3	0	0	0	0	0	0	0	0	0
CH4	0	0	0	0	0	0	0	0	0
CH5	0	0	0	0	0	0	0	0	0

Quality assessment of fish samples

Table 2 summarizes the quality assessment using the Quality Index Method (QIM). The quality assessment revealed that all Bangus, Tilapia, and Hito samples received a score of 0, indicating high freshness. Among them, CG3 scored the highest with 11 points, while the other Galungong species scored 6 or lower. Notably, CG3 displayed the most significant deterioration, characterized by a burst belly, a musty/sour odor, and a sunken appearance. Key freshness indicators include clear, bright eyes, firm flesh, and a subtle, briny aroma. Fish with an overly fishy or sour smell are likely not fresh.

The Quality Index method has been employed to assess fish freshness based on several sensory parameters and attributes that undergo noticeable changes during the degradation process (Laureti *et al.*, 2023). This method operates on the premise that assessors may not gauge perfection levels precisely but can readily detect deviations from it (Hyldig *et al.*, 2007). The method offers several advantages, including the ability to determine fish suitability for consumption, predict storage duration and shelf life, integrate time and temperature data, provide species-specific evaluation, be non-destructive, and require no specialized equipment (Freitas *et al.*, 2021).

Roundscad (galunggong), St. Peter Fish (tilapia), Milkfish (Bangus), and Mudfish (hito) stand as four prominent commercial fish species in the Philippines. While Tilapia and Hito thrive in freshwater environments, particularly in areas like Isabela, where aquaculture is prevalent, Galunggong, in contrast, is a marine species sourced from the waters of Cagayan or supplied through the Navotas fishport. This distinction significantly influences the freshness of these fish varieties. The geographical origin of Galunggong necessitates careful processing and preservation efforts, given the considerable distance it travels to reach consumers and markets, ultimately playing a pivotal role in maintaining its quality.

pH of fish samples

Table 3 presents the pH values of the fish samples. Knowledge about the pH of fish meat may give valuable information about its condition. Testing the pH of fishes is significant for food security for various reasons. Firstly, maintaining an optimal pH range in fish farming ensures the health and well-being of fish, which directly impacts the quality and safety of fish products for human consumption (Yokogawa, n.d.). A balanced pH environment promotes better growth, behavior, and overall appearance of fish, which is essential for meeting the increasing demand for fish as a food source (Atlas Scientific, 2021). Secondly, stable pH levels help prevent the growth of harmful microorganisms in fish and seafood products, reducing the risk of foodborne illnesses and ensuring the safety of these products for consumers (McGlynn, 2016).

Table 3. pH of fish samples

Fish	pH			Mean
	1	2	3	
Bangus	6.68	6.39	6.21	6.43
Galunggong	6.56	6.25	6.27	6.36
Tilapia	5.80	5.64	5.76	5.73
Hito	6.86	6.71	6.64	6.74

The mean pH values indicate the acidity or alkalinity of the fish meat. It is important to note that the pH of fish meat can vary depending on factors such as species, diet, and environmental conditions. The pH of fish meat can serve as an indicator of freshness and quality, as it is influenced by various factors such as the fish's diet, environmental conditions, and the presence of spoilage microorganisms (Elshehawy *et al.*, 2016). As fish spoil, metabolites such as volatile base nitrogen are produced, which can cause changes in the pH of the fish meat (Do-Yeong *et al.*, 2023). This method can provide a simple and reliable way to assess the freshness of fish during storage. Previous studies elucidate that pH is affected by TVB-N accumulation in a fish's microbial activity. TMA and DMA formation generally increase fish pH during storage (Gram *et al.*, 1996); thus, pH escalation is associated with storage spoilage. However, it is important to note that pH alone should not be the sole parameter used to assess the freshness and quality of fish meat. Other factors, such as microbial load, lipid oxidation, and sensory evaluation, should also be considered to obtain a comprehensive understanding of the fish's freshness and quality (Chun *et al.*, 2014). By combining pH measurements with other assessment methods, a more accurate evaluation of fish freshness can be achieved, ensuring the safety and quality of fish products for consumers.

The acceptable pH range for fish themselves, rather than their water or culture, depends on the species of fish. Most freshwater tropical fish thrive between 6.8 and 7.8, but some species come from areas where pH can be significantly higher or lower than these values (Florida Department of Agriculture, n.d.). It is essential to consider the specific pH requirements of each fish species, as they have evolved in different environments with varying pH levels.

Heavy metal content of fish samples (Cd and Pb)

It was found that popular fish varieties such as Hito, Bangus, Galunggong, and Tilapia exhibited levels below 0.250 µg/g of lead and below 0.075 µg/g of cadmium (Table 4). These results are significant as they indicate that the fish samples analyzed fall within the permissible limits set by regulatory authorities such as the Food and Drug Administration (FDA). The established limits are based on extensive research and risk assessments to ensure consumer safety. Elevated levels of heavy metals in food, especially in fish, can pose serious health risks upon consumption, including organ damage and neurological disorders.

Table 4. Heavy metal content of fish samples

Fish	Pb	Cd
Bangus		
Galunggong	<0.250 (µg/g)*[a]	<0.075 (µg/g)*[a]
Tilapia		
Hito		

*reporting limit [a]within permissible limit

In terms of safety, the findings suggest that the fish sold in Tuguegarao City's wet markets are generally safe for consumption in regard to cadmium and lead levels. Fish husbandry owners and workers need to reevaluate their agricultural and manufacturing practices and the fish vendors must strictly abide with the protocols relative to proper handling of fish to prevent contamination as small amounts of lead and cadmium consumed over time can cause adverse health effects among children and adults. Lead exposure among children causes damage to the central nervous system, slowed growth and development, behavioral, hearing, and speech problems whereas adults may experience high blood pressure as well as kidney, brain, and reproductive issues. Cadmium exposure poses serious health risks to both children and adults, affecting multiple organ systems and increasing the likelihood of chronic diseases and other health problems over time.

Hence, continuous monitoring and periodic testing are essential to ensure compliance with safety standards, as heavy metal contamination can vary over time due to environmental factors and other sources of pollution.

Further tests may include analyzing additional heavy metals such as mercury, arsenic, and chromium, which are also of concern in seafood. Additionally, assessing the bioavailability of these heavy metals and their potential cumulative effects on human health would provide a more comprehensive understanding of the safety of consuming fish from the area.

Conclusion

This study highlights the importance of assessing the physicochemical properties and heavy metal contamination of fish sold in wet markets. The results show that the fish samples from Tuguegarao City are generally fresh and of good quality, with heavy metal levels within permissible limits. These findings are crucial for consumers, vendors, and regulatory bodies to ensure the safety and quality of fish products. The study also underscores the need for continuous monitoring and proper handling practices to maintain fish quality and prevent contamination. Future research should focus on a broader range of heavy metals and include other contaminants to provide a more comprehensive assessment of fish safety. Additionally, investigating the impact of different handling and storage practices on fish quality can help develop better strategies to ensure the freshness and safety of fish sold in wet markets.

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