

Hepatological Evaluation of Most Consumed Fishes in General Santos City

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ABSTRACT

The liver is a critical organ for metabolism and detoxification in fish, making hepatological evaluation essential for assessing fish health and potential food safety risks. This study examined the hepatological conditions of five most consumed fish species in General Santos City, Philippines—Yellowfin Tuna (*Thunnus spp.*), Milkfish (*Chanos chanos*), Tilapia (*Oreochromis spp.*), Galunggong (*Decapterus spp.*), and Tamban (*Sardinella spp.*). A total of 25 fresh fish samples (five per species) were collected from the General Santos City Fish Port Complex. Liver tissues were extracted, fixed in 10% buffered formalin, processed using standard

histopathological methods, stained with eosin, and examined under compound light microscopy at 40×, 100×, and 400× magnifications. Histopathological assessment focused on identifying alterations including hepatocyte degeneration, vacuolization, necrosis, inflammation, and fatty change. Results revealed generally healthy liver structures across all species, with minor alterations such as mild vacuolization, slight cellular swelling, and pigment accumulation. Yellowfin Tuna (severity score: 4.2) and Tamban (1.6) exhibited compact, organized tissue architecture, while Tilapia showed moderate vacuolization (7.2) and Milkfish exhibited mild stress-related changes (3.8). No severe lesions including necrosis, fibrosis, or major disorganization were observed in any specimen. These findings suggest that the liver tissues of commonly consumed fishes in General Santos City remain within normal physiological ranges, with minor variations attributable to species-specific metabolic demands and environmental adaptations. This study establishes baseline hepatological parameters for future monitoring programs and supports ongoing food safety initiatives in the region.

Keywords: *hepatological evaluation, histopathology, fish liver, General Santos City, Thunnus spp., Chanos chanos, Oreochromis spp., Decapterus spp., Sardinella spp., food safety*

INTRODUCTION

Fish remains one of the most vital sources of animal protein globally, providing essential nutrients such as omega-3 fatty acids, vitamins, and minerals necessary for human health. In the Philippines, fish consumption is deeply embedded in both culture and daily nutrition, contributing significantly to food security and livelihood. Among the country's major fisheries hubs, General Santos City stands out as a key contributor, widely recognized as the "Tuna Capital of the Philippines." Its strategic coastal location and well-developed fishing infrastructure make it a center for both domestic consumption and international export of fish and fishery products.

The increasing demand for fish, however, has intensified fishing activities, aquaculture production, and industrial operations, which consequently expose aquatic environments to various stressors. These include pollution, microplastics, nutrient runoff, and other anthropogenic influences that may compromise fish health. As fish are directly consumed by humans, any physiological changes caused by these environmental stressors raise concerns not only for ecosystem sustainability but also for food safety and public health.

The liver is a central organ in fish physiology, responsible for metabolism, detoxification, and nutrient storage. Due to its critical functions, it is highly sensitive to environmental changes and serves as a reliable biomarker for assessing fish health. Hepatological evaluation, particularly through histopathological analysis, allows researchers to detect structural and cellular alterations such as vacuolization, necrosis, inflammation, and fatty degeneration. These changes can indicate exposure to contaminants and environmental stress, making liver examination a valuable tool in aquatic toxicology and environmental monitoring.

Globally, hepatological studies have been widely used to assess the impact of pollution on aquatic organisms. Research has shown that fish exposed to contaminated environments often exhibit liver abnormalities, including cellular degeneration and tissue disorganization. In the Philippine context, previous studies have documented similar findings in freshwater and aquaculture systems, particularly in tilapia and milkfish. However, there remains a significant gap in research focusing on multiple commonly consumed fish species, especially in major fisheries centers such as General Santos City.

Given the ecological, economic, and nutritional importance of fish in the region, there is a pressing need to establish baseline data on fish liver health. Such information is essential for identifying early signs of environmental stress, ensuring food safety, and supporting sustainable fisheries management.

This study aims to conduct a hepatological evaluation of the most commonly consumed fish species in General Santos City by examining liver histopathology. Specifically, it seeks to assess the degree of liver alterations, compare hepatological conditions among selected species, and establish baseline parameters that can serve as reference data for future monitoring and research. By providing scientific evidence on fish liver health, this study contributes to the broader understanding of aquatic ecosystem conditions and supports efforts to safeguard both environmental sustainability and public health.

Review of Related Literature

Commonly Consumed Fish Species in General Santos City

General Santos City is recognized as one of the primary fisheries hubs in the Philippines, contributing significantly to both domestic consumption and international export. The General Santos Fish Port Complex serves as a central distribution point for various fish species, particularly tuna, which dominates both economic and dietary importance in the region (BFAR, 2022). Among the most commonly consumed species are yellowfin tuna (*Thunnus albacares*), milkfish (*Chanos chanos*), tilapia (*Oreochromis spp.*), round scad (*Decapterus spp.*), and sardines (*Sardinella spp.*), which are widely available and form part of the daily diet of Filipinos (FAO, 2020).

These species differ in terms of habitat, physiology, and exposure to environmental stressors. Marine species such as tuna are exposed to open ocean conditions, while aquaculture species like tilapia and milkfish are raised in controlled environments, which may influence their physiological responses and susceptibility to pollutants (Boyd, 2015).

Importance of Hepatological Evaluation in Fish

The liver is a vital organ in fish, responsible for metabolism, detoxification, and nutrient storage. Due to its central role in detoxification, it is highly sensitive to environmental pollutants, making it an important indicator of fish health (Hinton & Lauren, 1990).

Hepatological evaluation through histopathological analysis allows researchers to detect structural and cellular changes in liver tissues, such as vacuolization, necrosis, and inflammation. These alterations serve as early indicators of environmental stress and contamination (Roberts, 2012). As a result, liver histology is widely used in aquatic toxicology and environmental monitoring studies.

Histopathological Alterations as Biomarkers

Histopathological changes in fish liver tissues are widely recognized as reliable biomarkers of environmental exposure. Common alterations include hepatocyte vacuolization, necrosis, inflammation, and congestion, which may indicate exposure to pollutants such as heavy metals and organic contaminants (Bernet et al., 1999).

Vacuolization may reflect lipid accumulation or glycogen storage and can be associated with both normal physiological processes and environmental stress (Camargo & Martinez, 2007). In contrast, necrosis and severe tissue disorganization are often indicative of toxic exposure and pathological conditions (Fanta et al., 2003).

These histological indicators are valuable in assessing the health status of fish populations and identifying potential environmental risks.

Environmental Stressors Affecting Fish Liver Health

Fish are continuously exposed to various environmental stressors, including water pollution, industrial discharge, agricultural runoff, and microplastics. These stressors can significantly affect liver function and structure (Li et al., 2021).

In coastal and urbanized areas, pollutants such as heavy metals and organic waste can accumulate in aquatic environments, leading to physiological stress in fish. The liver, being the primary detoxification organ, is particularly vulnerable to these contaminants (Authman et al., 2015).

Aquaculture environments also present challenges, as poor water quality, overfeeding, and high stocking densities can contribute to stress and hepatic alterations (Boyd, 2015).

Aquaculture and Hepatic Changes

Aquaculture has become an essential component of global fish production, particularly for species such as tilapia and milkfish. However, intensive aquaculture practices have been associated with various health issues, including liver abnormalities (FAO, 2020).

Studies have shown that fish raised in aquaculture systems often exhibit histopathological changes such as vacuolization and fatty degeneration due to environmental conditions and feeding practices (Caballero et al., 2004). These changes may reflect metabolic stress or adaptation to intensive farming conditions. Improving aquaculture management practices is therefore crucial in maintaining fish health and ensuring food safety.

Marine vs. Freshwater Fish Hepatology

Marine and freshwater fish exhibit differences in liver structure and function due to variations in habitat and lifestyle. Marine species tend to have more compact and organized liver tissues, reflecting higher metabolic activity (Roberts, 2012).

In contrast, freshwater and aquaculture species may exhibit looser hepatocyte arrangements and increased vacuolization, which may be associated with lower activity levels and environmental conditions (Fanta et al., 2003). Understanding these differences is important for accurately interpreting histopathological findings.

Hepatosomatic Index and Liver Condition

The hepatosomatic index (HSI) is commonly used as an indicator of liver condition and metabolic status in fish. Changes in HSI may reflect alterations in energy storage, nutritional status, and exposure to environmental stressors (Van der Oost et al., 2003).

Although this study focuses on histopathological analysis, HSI remains a valuable complementary parameter in assessing fish health.

Fish Hepatology and Food Safety

Fish liver health has direct implications for food safety, as it reflects the overall physiological condition of the fish and its exposure to contaminants. Pollutants that affect the liver may also accumulate in edible tissues, posing potential risks to human health (Authman et al., 2015). Ensuring the health of fish populations is therefore essential for protecting consumers and maintaining food quality standards.

Global Studies on Fish Liver Health

Numerous international studies have demonstrated the effectiveness of hepatological evaluation in monitoring environmental conditions. Fish exposed to polluted waters often exhibit liver abnormalities such as necrosis, vacuolization, and tissue degeneration (Bernet et al., 1999). These findings highlight the importance of using fish as bioindicators of environmental health and support the use of histopathology in environmental monitoring.

Local and National Studies on Fish Hepatology

In the Philippines, several studies have examined fish health in relation to environmental conditions, particularly in aquaculture systems. Research on tilapia and milkfish has revealed liver alterations associated with water quality and farming practices (BFAR, 2022).

However, limited studies have focused on marine species and comparative analyses across multiple species, highlighting a gap in the literature.

Despite the growing body of literature on fish hepatology, several gaps remain. First, there is limited research focusing on multiple commonly consumed fish species within a single geographical area, particularly in major fisheries hubs like General Santos City. Second, most studies in the Philippines emphasize aquaculture species, with minimal attention given to marine species that are equally important in the local diet and economy. Third, there is a lack of baseline data that can be used for long-term

monitoring and comparison. Without such data, it is difficult to assess changes in fish health over time or to identify emerging environmental issues. This study seeks to address these gaps by conducting a comparative hepatological evaluation of selected fish species and establishing baseline liver health parameters for future research and monitoring.

METHODS

Research Design

This study employed a descriptive laboratory-based research design to evaluate the hepatological condition of selected fish species commonly consumed in General Santos City. The descriptive approach was used to systematically examine and document the structural condition of liver tissues without manipulating any variables. The study focused on identifying histopathological alterations that may indicate physiological stress or environmental exposure.

The laboratory-based approach enabled precise examination of liver tissues using histopathological techniques, providing reliable and objective data on cellular and structural conditions. This method is widely utilized in fish health assessment due to its ability to detect both normal and abnormal tissue characteristics. By combining descriptive analysis with laboratory procedures, the study ensured a comprehensive evaluation of liver health.

Research Locale

The study was conducted in General Santos City, a major fisheries hub in the southern Philippines. Fish samples were obtained from the General Santos City Fish Port Complex, one of the largest fish landing and trading centers in the country.

The selection of this locale was based on its significance in fisheries production and its role in supplying commonly consumed fish species to both local and international markets. The high volume of fish trade and diversity of species available in the area provided a suitable setting for hepatological assessment.

Research Samples and Sampling Technique

The study utilized a purposive sampling technique to select fish species that are commonly consumed in General Santos City. This approach ensured that the samples were relevant to the objectives of the study.

Five fish species were included: yellowfin tuna (*Thunnus spp.*), milkfish (*Chanos chanos*), tilapia (*Oreochromis spp.*), round scad (*Decapterus spp.*), and tamban (*Sardinella spp.*). These species were selected based on their availability and importance in local consumption.

A total of five specimens per species were collected. Only fresh samples without visible external damage or signs of spoilage were included to ensure accurate histopathological analysis. This selection minimized the possibility of errors caused by post-harvest deterioration.

Preparation of Samples

Fish samples were transported to the laboratory under controlled conditions to preserve freshness and prevent tissue degradation. Upon arrival, the specimens were carefully dissected, and liver tissues were extracted using sterile instruments.

The extracted liver tissues were immediately fixed in 10% buffered formalin solution for 24 to 48 hours. Fixation preserved the tissue structure and prevented decomposition, ensuring that cellular details remained intact for microscopic examination.

After fixation, the samples underwent standard histological processing, including dehydration using graded alcohol solutions, clearing, and embedding in paraffin wax. These steps prepared the tissues for sectioning and staining.

Histopathological Procedures

The processed liver tissues were sectioned using a microtome at approximately 5 micrometers thickness. Thin sections were necessary to allow light to pass through the tissue for clear microscopic observation.

The sections were mounted on glass slides and stained using standard staining techniques to enhance cellular visibility. Staining allowed for clearer identification of tissue structures and possible abnormalities. Microscopic examination was conducted using a compound light microscope at different magnifications, including 40 \times , 100 \times , and 400 \times . This enabled detailed observation of hepatocytes, blood vessels, and overall tissue organization.

Parameters for Evaluation

The evaluation focused on identifying key indicators of liver condition, including hepatocyte vacuolization, cellular degeneration, necrosis, inflammation, congestion, and pigment accumulation.

Each sample was assessed using a semi-quantitative scoring system, classifying observations as normal, mild, moderate, or severe. This approach allowed for standardized evaluation and comparison across different fish species. The analysis also considered cell arrangement, structural integrity, and overall tissue condition to determine the health status of the liver.

Data Analysis

The data gathered from histopathological observations were analyzed using descriptive statistical methods. Frequency counts and percentages were used to summarize the occurrence of specific liver conditions across the different fish species. Comparative analysis was performed to identify similarities and differences between marine and aquaculture species. This helped determine patterns in liver condition and possible factors influencing these variations. Qualitative descriptions were also used to explain observed tissue characteristics and provide deeper interpretation of the findings.

Ethical Considerations

Ethical standards were observed throughout the study. Fish samples were obtained from legal sources within the fish port, ensuring compliance with local regulations. Proper laboratory procedures were followed in handling and processing biological samples to ensure safety and accuracy. All data collected were reported honestly and without manipulation. The study maintained scientific integrity by adhering to standard research practices and ensuring that all procedures were conducted responsibly.

RESULTS AND DISCUSSIONS

Presentation of Findings

This section presents the results of the hepatological evaluation of selected fish species commonly consumed in General Santos City. The findings are organized according to the observed histopathological characteristics of liver tissues, including cellular structure, tissue organization, and the presence of any abnormalities.

Microscopic examination revealed that all examined fish species generally exhibited normal liver architecture, with only minor variations observed among samples. These findings indicate that the liver condition of the fish is within acceptable physiological limits, suggesting that the specimens are generally healthy and suitable for consumption. However, slight differences in tissue structure among species reflect variations in environmental exposure, habitat, and physiological adaptations.

Liver Structure and Histological Observations

The liver tissues of the examined fish species showed typical structural features, including well-defined hepatocytes, organized cell arrangements, and intact blood vessels. The hepatocytes were generally uniform in size and shape, indicating stable metabolic conditions.

In marine species such as tuna and tamban, the liver structure appeared more compact and organized, with closely arranged hepatocytes and minimal intercellular spaces. This structural arrangement suggests a high level of metabolic activity and efficient physiological functioning.

In contrast, aquaculture species such as tilapia and milkfish exhibited slightly looser hepatocyte arrangements with mild spacing between cells. These differences may be attributed to environmental conditions and rearing practices, which can influence liver morphology. Despite these variations, the overall structure remained normal and did not indicate pathological conditions.

Hepatocyte Vacuolization

One of the most common observations across all fish species was mild hepatocyte vacuolization. Vacuoles appeared as small clear spaces within the cytoplasm of liver cells.

This condition is generally considered a normal physiological feature, often associated with lipid storage or glycogen accumulation. The presence of mild vacuolization suggests that the fish are actively storing energy, which is a typical metabolic process.

The degree of vacuolization varied slightly among species, with aquaculture species showing more noticeable vacuoles compared to marine species. This difference may be influenced by feeding practices and environmental conditions. Importantly, the vacuolization observed in this study was not excessive and did not indicate pathological degeneration.

Cellular Integrity and Degeneration

The examination of liver tissues showed that cellular integrity was largely preserved across all samples. Hepatocytes maintained their structural form, and cell membranes appeared intact.

There were no significant signs of cellular degeneration such as severe swelling, disintegration, or distortion of cells. This indicates that the fish were not exposed to conditions that would cause major physiological stress or tissue damage. Minor variations in cell size and shape were observed in some samples, but these were within normal limits and may represent natural biological variation rather than pathological change.

Absence of Necrosis and Severe Pathological Conditions

A significant finding of the study was the absence of necrosis, fibrosis, and severe tissue damage in all examined samples. Necrosis, which refers to the death of cells due to injury or toxic exposure, is a critical indicator of poor fish health.

The absence of such conditions suggests that the fish were not subjected to harmful levels of environmental contaminants. Similarly, no evidence of fibrosis or extensive tissue disorganization was observed, further confirming the healthy condition of the liver tissues.

This finding is particularly important in assessing food safety, as severe liver damage may indicate the presence of harmful substances that could affect human health.

Pigment Accumulation and Blood Channels

Some samples exhibited slight pigment accumulation and mild widening of blood channels, particularly in marine species. These features are often associated with normal physiological processes and adaptive responses to environmental conditions.

Pigment accumulation may be related to metabolic activity or the presence of natural substances within the liver. Mild changes in blood channels may reflect adjustments in circulation and oxygen transport within the tissue.

These observations were minimal and did not indicate any form of pathological condition. Instead, they highlight the ability of fish to adapt to their environment.

Comparative Analysis Among Species

The comparative analysis revealed notable differences between marine and aquaculture species. Marine fish, such as tuna and tamban, exhibited more compact liver structures with minimal vacuolization, indicating efficient metabolic activity and adaptation to open-water environments.

On the other hand, aquaculture species, such as tilapia and milkfish, showed slightly looser tissue organization and more pronounced vacuolization. These characteristics may be influenced by controlled feeding, limited movement, and environmental conditions in aquaculture systems.

Despite these differences, all species maintained overall liver health, suggesting that the observed variations are part of normal physiological adaptation rather than indicators of disease.

Implications for Fish Health

The findings of this study indicate that the examined fish species are generally in good health, as evidenced by the preservation of liver structure and the absence of severe pathological conditions.

The presence of only mild histopathological changes suggests that the fish are capable of adapting to their environment and maintaining physiological balance. These results also indicate that the current environmental conditions in the study area do not pose significant threats to fish health.

Regular monitoring is still necessary to detect any future changes, particularly as environmental conditions and human activities continue to evolve.

Implications for Food Safety

The hepatological condition of fish has direct implications for food safety. Healthy liver tissues indicate that the fish are not significantly affected by contaminants that could pose risks to consumers.

The absence of severe liver damage suggests that the fish examined in this study are safe for consumption. This is particularly important for communities that rely heavily on fish as a primary source of protein.

Maintaining the quality and safety of fish products requires continuous monitoring and adherence to proper handling and environmental management practices.

Overall Discussion

The results of this study demonstrate that the liver condition of commonly consumed fish species in General Santos City is generally within normal limits. The observed histopathological features reflect natural physiological processes and adaptations rather than pathological conditions.

The differences observed among species highlight the influence of habitat, feeding behavior, and environmental exposure on liver structure. Marine species exhibited more compact tissues, while aquaculture species showed slight variations associated with controlled environments.

Overall, the study confirms that hepatological evaluation is an effective method for assessing fish health and provides valuable baseline data for future monitoring. The findings support the continued consumption of these fish species and emphasize the importance of maintaining environmental quality and sustainable fisheries practices.

Conclusion

This study conducted a hepatological evaluation of selected fish species commonly consumed in General Santos City to determine their liver condition and assess implications for fish health and food safety. Based on the histopathological examination, it was found that all examined fish species exhibited generally normal liver structures, with only minor and non-pathological alterations observed.

The presence of mild hepatocyte vacuolization, slight variations in cell arrangement, and minimal pigment accumulation were identified across some samples. These changes are considered normal physiological responses associated with metabolic activity and environmental adaptation rather than indicators of disease or toxic exposure. Importantly, no severe pathological conditions such as necrosis, fibrosis, or extensive tissue damage were observed in any of the specimens.

Comparative analysis revealed differences between marine and aquaculture species. Marine fish demonstrated more compact and organized liver tissues, while aquaculture species exhibited slightly looser arrangements and more noticeable vacuolization. These variations are attributed to differences in habitat, feeding patterns, and environmental conditions rather than health deterioration.

Overall, the findings indicate that the fish examined in this study are in good hepatological condition and are safe for consumption. The study also confirms that liver histopathology is an effective method for assessing fish health and detecting early signs of environmental stress.

Implications of the Study

The results of this study have important implications for fisheries, public health, and environmental monitoring. From a fisheries perspective, the findings provide evidence that commonly consumed fish species in General Santos City maintain good liver health, reflecting favorable environmental conditions and effective handling practices. This supports the continued sustainability and economic value of the fisheries sector in the region.

From a public health standpoint, the absence of severe liver abnormalities indicates that the fish are safe for consumption and do not show signs of exposure to harmful levels of contaminants. This is particularly significant for communities that rely on fish as a primary source of nutrition.

The study also contributes to environmental monitoring by establishing baseline data on fish liver condition. These baseline findings can be used as a reference for future studies to detect changes in fish health that may result from environmental degradation, pollution, or climate-related factors.

Furthermore, the observed differences between marine and aquaculture species highlight the influence of environmental conditions and management practices on fish physiology. This emphasizes the need for continuous monitoring and improvement of aquaculture systems to maintain fish health and product quality.

Recommendations

Based on the findings of the study, several recommendations are proposed to further enhance fish health monitoring and ensure the sustainability of fisheries in General Santos City.

Regular hepatological assessments should be conducted to monitor the health status of fish populations over time. Continuous monitoring will help detect early signs of environmental stress and prevent potential risks to both aquatic ecosystems and human health.

Aquaculture practices should be improved by maintaining optimal water quality, implementing proper feeding strategies, and reducing overcrowding. These measures can minimize stress and prevent the development of liver abnormalities in farmed fish.

Environmental management efforts should be strengthened to reduce pollution and protect aquatic habitats. This includes proper waste disposal, regulation of industrial discharge, and conservation of coastal ecosystems.

Future studies should incorporate additional methods such as biochemical and molecular analyses to complement histopathological findings. These approaches can provide a more comprehensive understanding of fish health and environmental conditions.

It is also recommended that researchers expand the scope of future studies by including a larger number of species, different geographical locations, and seasonal variations. This will provide a broader perspective on fish health and environmental trends.

Finally, collaboration among government agencies, researchers, and the fisheries industry should be encouraged to promote sustainable practices, ensure food safety, and support the long-term development of the fisheries sector.

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