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# Feasibility analysis of suckermouth catfish *Pterygoplichthys pardalis* (Castelnau, 1855) as a feed ingredient for cultivated fish

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## ABSTRACT

**Background:** *Pterygoplichthys pardalis* (Castelnau, 1855) has been known to dominate Lake Sidenreng. The abundant presence of this species has not been optimally utilized and has caused negative impacts on the ecosystem. This study aims to evaluate the heavy metal content of mercury (Hg), cadmium (Cd), and lead (Pb), as well as to analyze the nutritional composition of suckermouth catfish meat. **Methods:** The research was conducted in July and August 2021 in Lake Sidenreng, Sidenreng Rappang Regency, South Sulawesi. Fish samples were obtained from fishermen at three stations: Wette'e, Teteaji, and Mojong. Heavy metal content was analyzed descriptively based on the maximum permissible limits of heavy metal contamination, while the nutritional composition was analyzed using proximate analysis. **Findings:** The results showed that the cadmium (Cd) and lead (Pb) levels in suckermouth catfish meat from July to August were below the heavy metal contamination limits, with Cd <0.01 µg/g and Pb ranging from <0.01 to 0.13 µg/g. Mercury (Hg) levels in July ranged from 0.0006 to 0.0119 µg/g, whereas in August, Hg levels exceeded the contamination limit, ranging from 0.2246 to 0.8223 µg/g. The nutritional composition of the fish meat showed high protein content (88.56–92.08%), ash content (3.19–7.46%), fat content (1.00–2.08%), and carbohydrate content (1.18–3.44%). **Conclusion:** The Cd and Pb levels in all sampling stations were within the acceptable limits. The Hg levels in July and in August at Wette'e were still within tolerable limits, while in Mojong and Teteaji in August, Hg levels exceeded the contamination threshold. The protein content of *P. pardalis* from Lake Sidenreng was relatively high, while the fat, carbohydrate, ash, and crude fiber contents were relatively low. **Novelty/Originality of this article:** This study provides new insights into the heavy metal contamination and nutritional composition of *P. pardalis* in Lake Sidenreng, which has not been extensively studied. The findings contribute to the assessment of the species' potential as a food source and highlight the environmental risks associated with heavy metal accumulation.

**KEYWORDS**: Lake Sidenreng; suckermouth catfish; nutritional composition; heavy metals; *Pterygoplichthys* spp.

## 1. Introduction

South Sulawesi is home to several lakes that have been utilized by local communities. One of these is Lake Sidenreng, located in Sidenreng Rappang Regency (Sidrap). This freshwater ecosystem holds significant potential as a source of fish, serving as an important resource for meeting the population's animal protein needs, increasing fishermen's income, and expanding employment opportunities for the surrounding community. During the dry

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season, this lake remains separate from Lake Tempe and Lake Buaya. However, during the rainy season, the three lakes merge, forming a water body of approximately 35,000 hectares.

*Pterygoplichthys pardalis* (Castelnau, 1855), as reported by Hasrianti (2020) and local residents, has been identified as the dominant fish species in Lake Sidenreng. Despite its abundance, this fish remains largely underutilized. Commonly known as the suckermouth catfish, *P. pardalis* is an introduced species originating from Central and South America (Kottelat et al., 1993). Over time, this species has spread widely across freshwater ecosystems throughout Indonesia. Its rapid adaptability and high tolerance to unfavorable environmental conditions have enabled it to proliferate at an accelerated rate (Tunjungsari, 2007). One of the key factors contributing to the adaptability of *P. pardalis* is the presence of an accessory respiratory organ known as the labyrinth organ. This specialized organ allows the species to survive in water bodies with low dissolved oxygen levels and even in polluted environments (Ariana, 2013).

However, the presence of this invasive species has led to significant ecological disruptions. The population explosion of *P. pardalis* has posed a substantial threat to native fish species, as their numbers continue to decline due to increased competition for resources. Chaicana & Jongphadungkiet (2012) found that *P. pardalis* preys on small fish and fish eggs, while Thalathiah & Palanisamy (2004) noted that members of the Cyprinidae family are particularly affected by its presence. Due to its high adaptability, *P. pardalis* has the potential to become an ecological pest, disrupting the balance of aquatic ecosystems (Wahyudewantoro, 2018). The continuous increase in the population of *P. pardalis* in Lake Sidenreng has contributed to the decline of commercially valuable fish species, subsequently leading to reduced income for local fishermen (Dewi et al., 2019).

Despite these ecological concerns, studies suggest that *P. pardalis* has considerable economic potential. Research by Munandar and Eurika (2016) indicates that this species possesses a high protein content, making it a viable alternative ingredient for fish feed production. However, its utilization must be approached with caution, as *P. pardalis* is known to accumulate heavy metals in its tissues (Pinem et al., 2016). Toxic heavy metals such as arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb) pose significant health risks. Among these, Cd and Hg are classified as highly toxic even at minimal concentrations (Riani, 2012). Given this concern, further research is necessary to evaluate the levels of heavy metal contamination, particularly mercury (Hg), cadmium (Cd), and lead (Pb), in *P. pardalis* from Lake Sidenreng. Additionally, an analysis of its nutritional composition based on proximate analysis is essential to determine its potential as a sustainable alternative resource.

According to data from the Central Statistics Agency (BPS) in 2020, the number of aquaculture households in Sidenreng Rappang Regency in 2019 was recorded at 2,288, with a total production output of 678.2 tons. However, the region's aquaculture potential remains underutilized compared to its available cultivation area. One of the major constraints is the high cost of fish feed, which is primarily due to the reliance on imported raw materials. As highlighted by Kordi (2010, as cited in Cahyoko et al., 2011), the development of locally available, cost-effective raw materials is essential for reducing dependence on imported feed components. In response to this challenge, several studies have explored alternative feed ingredients that are both sustainable and economically feasible. For instance, the use of locally sourced aquatic organisms, such as *P. pardalis*, could offer a viable solution due to their abundance and nutritional value. Additionally, optimizing the use of indigenous species may enhance food security while minimizing production costs for local fish farmers. Therefore, this study aims to provide comprehensive information on the quality of *P. pardalis* by assessing its heavy metal content and nutritional composition. The findings of this study are expected to serve as a valuable reference for future research and policy development, particularly in optimizing the utilization of this species as an alternative resource in aquaculture and fisheries. Furthermore, promoting the adoption of such alternatives could contribute to the long-term sustainability and economic resilience of the aquaculture sector in the region.

## 2. Methods

This research was conducted from July to August 2021 at Lake Sidenreng, Sidenreng Rappang Regency, South Sulawesi. The fish sampling locations were obtained from catches in three different sites: Wette'e Village, Teteaji, and Mojong Village. The dissection process of the suckermouth catfish *Pterygoplichthys pardalis* (Castelnau, 1855 as cited at Chaichana & Jongphadungkiet, 2012) was carried out in the Fisheries Biology Laboratory, Department of Fisheries, Faculty of Marine and Fisheries Science. The heavy metal analysis was conducted at the Makassar Health Laboratory Center, while the proximate analysis was performed in the Chemistry and Animal Feed Laboratory, Faculty of Animal Science, Universitas Hasanuddin.

The materials and equipment used in this study are presented in Tables 1and 2. Table 1 shows the two main types of materials used in this study, namely suckerfish (Suckermouth catfish) meat and ice cubes. Suckerfish meat was used as the main test material in laboratory analysis, while ice cubes served to maintain the freshness of the samples during collection and prior to further analysis. The selection of these materials is important to ensure that the results obtained reflect optimal sample conditions and are not contaminated by environmental temperatures.

Table 1. Materials used in the study

| No | Material | Specification | Function |
|---|---|---|---|
| 1 | Suckermouth catfish | Fish meat | Primary test material |
| 2 | Ice cubes | Water | Maintain sample freshness before laboratory analysis |

Table 2 details the various equipment used to support the research process. A plastic coolbox was used as a temporary storage place for the fish meat before it was taken to the laboratory. An aluminum knife was used for the dissection process to obtain the required meat samples. Plastic containers were used to store the samples after dissection. A metal freezer is used to store samples at low temperatures to maintain meat quality. A metal digital scale is used to weigh samples accurately, and a plastic bucket serves as a container for storing sapu-sapu fish before further processing. All of this equipment is designed to maintain sample integrity and support the validity of laboratory analysis results.

Table 2. Equipment used in the study

| No | Equipment | Specification | Function |
|---|---|---|---|
| 1 | Coolbox | Plastic | Temporary storage for fish meat samples before laboratory analysis |
| 2 | Knife | Aluminum | Dissection tool |
| 3 | Sample plastic | Plastic | Storage for fish meat samples |
| 4 | Freezer | Metal | Storage for fish meat samples |
| 5 | Digital scale | Metal | Weighing fish meat samples |
| 6 | Bucket | Plastic | Container for the suckermouth catfish |

*2.3 Research procedures*

Fish samples were collected from fishermen's catches using an experimental gillnet operating in Lake Sidenreng. The sampling was conducted at three stations: Wette'e Village, Teteaji, and Mojong Village. Sampling was carried out twice over two months with a one-month interval. The collected fish were placed in a coolbox filled with ice to maintain freshness until laboratory analysis.

The preserved samples then underwent a standardized analysis protocol. First, the muscle tissue is carefully separated to ensure consistency in testing. This prepared material was then used for heavy metal detection via AAS and proximate composition analysis to evaluate nutritional quality.

The fish samples were dissected monthly to obtain fish meat for analysis. Heavy metal analysis was conducted using Atomic Absorption Spectrophotometry (AAS) to determine the concentration of Hg, Cd, and Pb. Proximate analysis was performed to measure protein, fat, nitrogen-free extract (BETN), crude fiber, ash, and moisture content in the fish meat.

*2.3.1 Heavy metal analysis in fish meat*

The heavy metal concentration in fish meat was determined following the procedures established by the Makassar Health Laboratory Center. A total of 2 grams of the sample was placed into a digestion block tube and mixed with 0.5 ml of distilled water. To prevent splashing and facilitate rapid acid reaction, the sample was digested with 10 ml of concentrated $HNO_3$ at approximately 100°C for two hours. After cooling for 15 minutes, 0.5 ml of perchloric acid ($HClO_4$) was gradually added to the solution, which was then reheated in the digestion block for an additional hour. The solution was then diluted with 50 ml of distilled water and filtered using Whatman No. 42 filter paper. The filtrate was prepared for analysis, and heavy metal standards were measured using AAS.

*2.3.2 Proximate analysis of fish meat*

Proximate analysis was conducted to assess the levels of protein, fat, nitrogen-free extract (BETN), crude fiber, ash, and moisture content in the suckermouth catfish meat. This analysis was performed at the Animal Feed Chemistry Laboratory, Faculty of Animal Science, Universitas Hasanuddin. A porcelain crucible was dried in an oven at 150°C for one hour, then cooled in a desiccator and weighed (x). A 5-gram sample (y) was weighed and placed into the crucible, then dried in an oven at 105°C for 4-6 hours. After drying, the sample was cooled in a desiccator and reweighed (z). The process was repeated three times until a constant weight was achieved. The moisture content was calculated using Equation (1):

$$Water\ content\ (\%\frac{b}{b}) = \frac{x+y-z}{y} \times 100\% \quad \text{(Eq. 1)}$$

The porcelain crucible was dried in an oven at 150°C for one hour, cooled in a desiccator, and weighed (x). A 5-gram sample (y) was placed into the crucible and incinerated on a hot plate until no smoke was observed. The sample was then transferred to a muffle furnace at 500-600°C. Once the sample turned white, it was cooled in a desiccator and weighed (z). The ash content was calculated using Equation (2):

$$Ash\ content = \frac{(z-x)}{y} \times 100\% \quad \text{(Eq. 2)}$$

2 ml sample extract of *P. pardalis* was pipetted and mixed with 2.75 ml of Lowry reagent B, incubated for 15 minutes, then mixed with 0.25 ml of Lowry reagent A and incubated for 30 minutes. The absorbance was measured at the maximum wavelength using a UV-Vis spectrophotometer. Protein content was determined using a BSA standard curve, following Equation (3):

$$y = ax + b \quad \text{(Eq. 3)}$$

1-gram sample was extracted using 10 ml of chloroform. A porcelain crucible was dried at 110°C for one hour, cooled in a desiccator, and weighed (b). The sample (5 ml) was placed in the crucible and dried in an oven at 105°C for four hours, then cooled in a desiccator and weighed until a constant weight was obtained (a). Fat content was calculated using Equation (4):

$$Fat\ content\ (\%\frac{b}{b}) = \frac{P \times (b-a)}{sample\ weight\ (gram)} \times 100\% \quad \text{(Eq. 4)}$$

The determination of carbohydrate content is carried out using the by-difference calculation method. The formula used to determine carbohydrate content is presented in Equation (5).

$$\%\,Carbohydrate = 100\% - \%\,(protein + fat + ash + water) \quad \text{(Eq. 5)}$$

*2.3.3 Determination of caloric value*

The formula used to determine caloric value per 100 gr sample is presented in equation (6). Calorie determination in samples was performed to determine the total energy contained in 100 grams of test material. The formula used refers to the standard approach developed by Widara (2012), taking into account the three main components that contribute calories in food, namely fat, protein, and carbohydrates. In this formula, each gram of fat is considered to contribute 9 calories, while protein and carbohydrates each contribute 4 calories per gram.

This calculation is based on the percentage of fat, protein, and carbohydrate content in the sample that has been analyzed previously. The final value of this calculation indicates the total energy that can be produced if 100 grams of the sample is consumed. This approach is widely used in nutritional analysis because it is simple, practical, and provides a general overview of the energy potential of a food item. By using this formula, the calculated calorie value can serve as an important indicator in assessing the potential of a sample as an energy source, particularly in the context of utilizing sapu-sapu fish meat as an alternative or commercial food source.

$$Caloric\ value = (9 \times \%\,fat + 4 \times \%\,protein + 4 \times \%\,carbs)\ calories \quad \text{(Eq. 6)}$$

*2.3.4 Determination of crude fiber content*

*P. pardalis*, weighing 2 grams, is measured and placed in a 750 mL Erlenmeyer flask. Then, 100 mL of 1.25% H2SO4 is added. The mixture is boiled for 30 minutes, followed by the addition of 200 mL of 3.25% NaOH. It is then boiled for another 30 minutes and hot-filtered using a Buchner filter containing pre-weighed filter paper.

The residue is subsequently washed sequentially with hot water, 1.25% H2SO4, hot water, and 96% alcohol. The filter paper and its contents are then placed in a pre-weighed porcelain crucible, dried in an oven at 105°C, and then ashed in a furnace at 500 - 600°C. The sample is cooled in a desiccator and weighed. The ashing, cooling, and weighing processes are repeated until a constant weight is obtained. The formula for determining crude fiber content is given in Equation (7).

$$\%\,Crude\ Fiber\ Content = \frac{A-B-C}{sample\ weight} \times 100 \quad \text{(Eq. 7)}$$

The weights used in the ash determination procedure are defined as follows: A represents the combined weight of the crucible, filter paper, and residue after ashing; B is the combined weight of the crucible and the ash alone; and C denotes the weight of the filter paper by itself. These measurements allow for precise calculation of the ash content by isolating the mass of the residue.

*2.3.5 Feasibility Instrument*

The feasibility of using sucker fish as a raw material for feed is assessed using a modified feasibility instrument from Saade et al. (2018), based on the standards of the Food and Drug Supervisory Agency (BPOM, 2018) and the Indonesian National Standard (SNI) 01-2715-1996/Rev.92 (BSN, 1996) (BSN, 1996).

Table 3. Feasibility instrument for sucker fish meal as feed raw material

| No | Parameter | Standard (BPOM[1] 2018) | | | Criteria | Score |
|---|---|---|---|---|---|---|
| A. | Heavy Metal Content | | | | | |
| 1 | Cadmium (Cd) | 0.10 | | | <0.10 | 7 |
| | | | | | 0.10 | 5 |
| | | | | | >0.10 | 3 |
| | | | | | <0.50 | 7 |
| 2 | Mercury (Hg) | 0.50 | | | 0.50 | 5 |
| | | | | | >0.50 | 3 |
| | | | | | <0.20 | 7 |
| 3 | Lead (Pb) | 0.20 | | | 0.20 | 5 |
| | | | | | >0.20 | 3 |
| *1 *1 Food and Drug Supervisory Agency (BPOM) | | | | | | |
| No | Parameter | Standard (SNI 01-2715-1996/Rev.92) | | | Criteria | Score |
| | | Grade I | Grade II | Grade III | | |
| B. | Nutrient Content | | | | | |
| | | | | | ≥65 | 7 |
| 1 | Protein | 65 | 55 | 45 | 55-65 | 5 |
| | | | | | 45-55 | 3 |
| | | | | | ≤45 | 1 |
| | | | | | 8-10 | 7 |
| 2 | Fat | 8 | 10 | 12 | 10-12 | 5 |
| | | | | | 12-14 atau 6-8 | 3 |
| | | | | | >14 atau <6 | 1 |
| 3 | Carbohydrate | 7 | 9 | 11 | 7-9 | 7 |
| | | | | | 9-11 | 5 |

Table 4 presents the classification of feed ingredient suitability based on evaluation scores obtained from predetermined parameters. This score range is used to assess the extent to which an ingredient, in this case sapu-sapu fish meat, can be used as a feed ingredient for aquaculture.If the feasibility score obtained is above 42, the material falls into the Highly Feasible category, meaning it is highly suitable for direct use as aquaculture feed raw material without additional treatment. Meanwhile, scores in the range of 27 to 41 fall into the Feasible category, indicating that the material has sufficient potential but requires certain treatments (such as processing or nutritional adjustments) before being used in feed formulations. Materials with scores below 27 are classified as Not Feasible, meaning they are not suitable for use as feed ingredients due to potentially low nutrient content or the risk of harming farmed fish. This scoring system is crucial in helping to determine whether a local ingredient, such as sapu-sapu fish, can be optimally and sustainably utilized in the aquaculture industry, particularly in the development of economical and environmentally friendly alternative feed.

Table 4. Feasibility score and recommendations

| Score | Feasibility Level | Description |
|---|---|---|
| >42 | Highly Feasible | Highly feasible as an aquaculture feed raw material |
| 27-41 | Feasible | Feasible as an aquaculture feed raw material after proper treatment |
| <27 | Not Feasible | Not feasible as an aquaculture feed raw material |

### *2.4 Data analysis*

Heavy metal content in each sampling station is analyzed descriptively based on the maximum permissible limits for heavy metal contamination. The nutrient content of each sample is analyzed descriptively based on proximate analysis results. The feasibility of sucker fish meal as a feed raw material is analyzed descriptively based on the sucker fish meal feasibility instrument.

# 3. Results and Discussion

## *3.1 Heavy metal content in Pterygoplichthys pardalis meat*

The concentration of heavy metals in the meat of *Pterygoplichthys pardalis* from the waters of Lake Sidenreng, Sidenreng Rappang Regency, during July and August 2021, is presented in Table 5.

Table 5. Heavy Metal Content in *Pterygoplichthys pardalis* Meat in July and August at Each Station in Lake Sidenreng

| Month | Station | Heavy Metal Type ( μg/g) | | |
|---|---|---|---|---|
| | | Cadmium | Mercury | Lead |
| July (2021) | Wettee | <0.01 | 0.0006 | 0.06 |
| | Mojong | <0.01 | 0.0088 | 0.09 |
| | Teteaji | <0.01 | 0.0119 | 0.13 |
| | Average | <0.01 | 0.007 | 0.093 |
| August (2021) | Wettee | <0.01 | 0.2246 | <0.01 |
| | Mojong | <0.01 | 0.5859 | 0.02 |
| | Teteaji | <0.01 | 0.8223 | 0.03 |
| | Average | <0.01 | 0.544 | 0.016 |
| BPOM (2018) | 0.10 | 0.50 | 0.20 | |

Based on Table 5, the cadmium (Cd) content in *Pterygoplichthys pardalis* meat obtained in July and August from all sampling stations generally exhibited low values, i.e., <0.01 μg/g. The low concentration of cadmium is below the maximum permissible heavy metal contamination level in fish, as established by BPOM (2018), which is 0.10 μg/g.

As shown in Table 5, the mercury (Hg) content in *Pterygoplichthys pardalis* meat sampled in July at all stations remained relatively low (<0.0119 μg/g). However, in August, the mercury levels were significantly higher (>0.2246 μg/g). The highest concentration of Hg was found in Mojong (0.5859 μg/g) and Teteaji (0.8223 μg/g) in August, exceeding the permissible contamination level of 0.50 μg/g for fish, as set by BPOM (2018).

The lead (Pb) content in *Pterygoplichthys pardalis* meat, as displayed in Table 5, ranged from <0.01 to 0.13 μg/g. The highest lead concentration was detected in Teteaji in July at 0.13 μg/g. This concentration remains below the permissible contamination limit of 0.20 μg/g for fish, as specified by BPOM (2018). Although lead levels are currently within safe limits, the presence of toxic metals, especially at low concentrations, needs to be further investigated in potential sources, such as urban runoff, old water pipes, or the use of leaded fuels in the region. Continuous monitoring is recommended to ensure that lead levels do not increase to dangerous levels in the future.

## *3.2 Proximate Composition of Pterygoplichthys pardalis Meat*

The proximate composition of Pterygoplichthys pardalis meat from each station in July and August 2021 in the waters of Lake Sidenreng, Sidenreng Rappang Regency, is presented in Table 6.

Table 6. Proximate Composition of Pterygoplichthys pardalis Meat in July and August at Each Station in Lake Sidenreng

| Month | Station | Moisture (%) | Crude Protein (%DM) | Crude Fat (%DM) | Ash (%DM) | Carbohydrates (%DM) | Carbohydrates (%DM) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Crude Fiber | NFE |
| July (2021) | Wettee | 80.08 | 92.08 | 1.00 | 3.19 | 3,01 | 1.08 | 1.93 |
| | Mojong | 79.90 | 90.13 | 1.49 | 4.94 | 3.44 | 1.09 | 2.35 |
| | Teteaji | 81.20 | 88.71 | 1.74 | 7.46 | 2.09 | 1.12 | 0.97 |
| | Average | 80.39 | 90.31 | 1.41 | 5.20 | 2.85 | 1.10 | 1.75 |
| | Wettee | 82.07 | 88.56 | 2.08 | 6.55 | 2.81 | 1.05 | 1.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| August (2021) | Mojong | 82.22 | 89.24 | 1.82 | 6.72 | 2.21 | 1.15 | 1.06 |
| | Teteaji | 81.76 | 91.22 | 1.41 | 6.18 | 1.18 | 0.75 | 0.43 |
| | Average | 82.02 | 89.67 | 1.77 | 6.48 | 2.07 | 0.98 | 1.08 |
| Fish Meal as Feed Raw Material (SNI 01-2715-1996/Rev.92) | | | | | | | | |
| Grade I | | 10 | 65 | 8 | 20 | 7 | 1.5 | |
| Grade II | | 12 | 55 | 10 | 25 | 9 | 2.5 | |
| Grade III | | 12 | 45 | 12 | 30 | 11 | 3 | |

The moisture content of Pterygoplichthys pardalis meat collected from Lake Sidenreng (Table 6) was highest in August at Mojong, measuring 82.22%. Conversely, the lowest moisture content was found in July at Mojong, recorded at 79.90%. The higher moisture content in August across all stations may be attributed to seasonal variations in water temperature or fish physiological changes, such as increased water retention during certain growth phases.

The highest crude protein content in Pterygoplichthys pardalis meat collected from Lake Sidenreng (Table 6) was observed in July at Wettee, reaching 92.08%. Meanwhile, the lowest protein content was found in August at Wettee, measuring 88.56%. The highest ash content in Pterygoplichthys pardalis meat (Table 6) was recorded at 7.46% in July at Teteaji. Conversely, the lowest ash content was found at 3.19% in July at Wettee. The highest crude fat content in Pterygoplichthys pardalis meat (Table 6) was found in August at Wettee, reaching 2.08%. Meanwhile, the lowest crude fat content was recorded at 1.00% in July at Wettee. The highest carbohydrate content in Pterygoplichthys pardalis meat (Table 6) was observed in July at Mojong, amounting to 3.44%. In contrast, the lowest carbohydrate content was recorded in August at Teteaji, measuring 1.18%. Overall, the carbohydrate content in July was higher than in August at all locations.

### *3.3 Feasibility of Pterygoplichthys pardalis fishmeal as feed ingredient*

The feasibility assessment of Pterygoplichthys pardalis fishmeal at each station in July and August 2021 in the waters of Lake Sidenreng, Sidenreng Rappang Regency. The total feasibility score for Pterygoplichthys pardalis meat obtained in July at each station was relatively high at 34. In contrast, the total score in August was lower, reaching 30. This difference most likely stems from the higher protein content and lower ash levels observed in July, which are more in line with premium fishmeal standards. However, even the August sample meets the basic requirements for feed use, provided it is mixed with complementary ingredients to balance the nutritional profile. Further research should explore processing techniques (e.g., drying, degreasing) to optimize consistency across seasons and improve economic viability for aquaculture feed production.

### *3.4 Discussion*

Lake Sidenreng is a freshwater ecosystem with great potential for fish production and has been utilized by the surrounding community. According to Hasrianti (2020) and local residents, one of the dominant fish species caught in Lake Sidenreng is the suckermouth catfish *P. pardalis* (Castelnau, 1855). The presence of this invasive fish species poses a threat to the population of native fish species. Since the emergence of the suckermouth catfish, which has been increasing year by year, the population of other consumable fish in Lake Sidenreng has declined, leading to a decrease in fishermen's income (Dewi et al., 2020).

Environmental pollution caused by heavy metals from anthropogenic sources is generally higher than natural sources entering the water bodies (Fukue et al., 2007). These pollutants originate from human activities such as waste disposal from ships, urban waste, mining, agriculture, and industrial waste (Bangun, 2005). The concentration of heavy metals tends to increase as the volume of metal-containing waste entering the water increases. Based on the results obtained in this study, the levels of cadmium (Cd) and lead (Pb) in the fish were generally below the heavy metal contamination limits set by BPOM (2018). The contamination limit for Cd is 0.10 μg/g, and for Pb, it is 0.20 μg/g. However, mercury (Hg) levels in August at the Mojong and Teteaji stations exceeded the contamination threshold. This increase in heavy metals is suspected to be due to rising human activities and agricultural activities, as mercury compounds are commonly used as fungicides. That the largest land use in Mojong is for rice fields.

Cadmium (Cd) is one of the heavy metals with low concentration levels. The concentration of Cd in suckermouth catfish meat caught in July and August at different locations in Lake Sidenreng was found to be <0.01 μg/g. Munandar and Eurika (2016) found Cd levels in fish meat from the Bedadung River, Jember, to be 0.167 μg/g. The low Cd concentration in this study is due to minimal cadmium pollution in the habitat of the suckermouth catfish. Generally, Cd pollution sources originate from industrial waste (Palar, 2008). Mercury (Hg) is considered the most toxic heavy metal in the environment (Jeong et al., 2024) and has a high bioaccumulation potential (Kumar et al., 2023). Mercury is released into the environment through industrial activities such as pharmaceuticals, pulp and paper preservation, agriculture, chlorine, and caustic soda production (Jaishankar et al., 2014). Mercury concentrations tend to fluctuate. In August, Hg levels were particularly high, especially at Mojong station (0.5859 μg/g) and Teteaji station (0.8223 μg/g), exceeding the heavy metal contamination threshold. This finding contradicts Amir et al. (2020), who found that suckermouth catfish in Wajo Regency, South Sulawesi, were safe for consumption as their Hg levels did not exceed the required limits. BPOM (2018) has set the maximum Hg contamination limit at 0.5 μg/g.

In agriculture, mercury compounds are used as fungicides, which contribute significantly to mercury poisoning in living organisms (Palar, 2008). Wide and open spraying activities cause many other organisms to be exposed to these toxic compounds. Thus, fungicide spraying not only kills fungi but also affects other living organisms. The mercury levels in July were lower than in August, possibly due to differences in mercury input from agricultural sources. Utsale et al. (2025) and Saenab et al. (2014) explained that the lower concentration of accumulated heavy metals could be due to sampling being conducted during the rainy season. This explanation aligns with the conditions during the collection of suckermouth catfish samples from Lake Sidenreng, which took place during the rainy season. Rainfall contributes to dilution, causing lower heavy metal concentrations in the water. Additionally, heavy metal concentration levels are influenced by the volume of heavy metal waste entering the water. The greater the waste input, the higher the heavy metal concentration in the water.

The lead (Pb) content in suckermouth catfish meat from Lake Sidenreng ranged between <0.01 -0.13 μg/g. Pb levels in suckermouth catfish tended to decrease at each station. Aksari et al. (2015) found that the average Pb concentration in the gills, liver, and muscles of suckermouth catfish in the Ciliwung River was 0.002571 μg/g, 0.005467 μg/g, and 0.001609 μg/g, respectively, which are below the SNI safety limits. Munandar and Eurika (2016) also found an average Pb content of 0.2563 μg/g in suckermouth catfish from the Bedadung River, Jember. The low Pb content may be due to minimal lead-containing pollutants entering the water. According to Azizah et al. (2018), motor vehicle waste such as oil, lubricants, and gasoline can contribute Pb contamination in water. BPOM (2018) has set the maximum Pb limit in fish at 0.20 μg/g. Based on this standard, the Pb levels in suckermouth catfish from Lake Sidenreng are still within safe limits.

Nutrients are chemical compounds in food that are essential for metabolism. According to Morris & Mohiuddin (2023), nutrients are classified into six categories: carbohydrates, proteins, fats, vitamins, minerals, and water. The moisture content in suckermouth catfish from Lake Sidenreng ranged from 79.90% to 82.22%, with the highest level recorded at Mojong in August (82.22%). Moisture content has an inverse relationship with fat content—fish with high moisture content tend to have lower fat content (Suzuki, 1991). The protein content in suckermouth catfish from Lake Sidenreng ranged from 88.56% to 92.08%, with the highest level found in Wettee in July (92.08% dry basis). High protein levels in fish are attributed to their structural function and energy source (Damayanti, 2005). The fat content in suckermouth catfish ranged from 1.00% to 2.08%, with the highest level found in Wettee in August (2.08%). Based on these values, the fish is classified as low-fat fish (<2%) (Sun, 2006). The fiber content in suckermouth catfish ranged from 0.75% to 1.15%, with the highest level recorded at Mojong in August (1.15%). Generally, fish are not rich in fiber compared to plant-based foods (Kusharto, 2006). The ash content, which indicates mineral composition, ranged from 3.19% to 7.46%, with the highest level recorded at Teteaji in July (7.46%). The high ash content is likely due to the fish's red-colored meat, which contains more minerals (Arias et al., 2004; Deman, 1977).

The feasibility of suckermouth catfish meal was assessed using a modified feasibility instrument by Saade et al. (2018). The maximum score was 56, and the minimum was 14. Based on the results, the total score for fish meal from fish caught in July at all stations in Lake Sidenreng was 34, while in August, it was 30. The lower score in August was due to the heavy metal content in Mojong and Teteaji stations exceeding the permissible limits.

## 4. Conclusions

Based on the findings presented in the previous chapters, several conclusions can be drawn regarding the presence of heavy metals and nutritional content in the flesh of suckermouth catfish (*Pterygoplichthys* sp.) found in Lake Sidenreng. The levels of cadmium (Cd) and lead (Pb) detected in fish samples collected from various stations within the lake remain within acceptable limits for human consumption. Similarly, mercury (Hg) concentrations in fish samples collected in July from all sampling locations and in August from the Wetee station were still within tolerable limits. However, mercury levels in samples taken from Mojong and Teteaji in August exceeded the contamination threshold, indicating potential environmental concerns in these areas. This increase in Hg levels may be related to anthropogenic activities such as agricultural runoff, gold mining, or improper waste disposal, which may contribute to the accumulation of heavy metals in aquatic ecosystems. Variations in contamination levels between months suggest a seasonal influence, possibly due to fluctuations in water flow, sedimentation or pollution inputs. Despite these local concerns, overall nutritional analysis of the fish including protein, fat and essential mineral content has shown that suckermouth catfish remains a viable food source if it comes from uncontaminated areas. To ensure long-term food safety, continuous monitoring and stricter environmental regulations should be implemented, especially in high-risk areas. In addition, public awareness campaigns on safe fish consumption and pollution mitigation strategies can help minimize health risks to local communities.

The dual findings relating to nutritional value and contamination risk have been able to help highlight the importance of context-appropriate management strategies. On the one hand, suckermouth catfish can contribute to food security if harvested from safe zones. However, on the other hand, uncontrolled pollution is threatening its long-term sustainability. Therefore, integrating nutritional assessment with environmental audits as proposed in further research will be key to sustainable utilization.

In terms of nutritional composition, the protein content in the flesh of suckermouth catfish from Lake Sidenreng was found to be relatively high, suggesting its potential as a valuable protein source. Conversely, the levels of fat, carbohydrates, ash, and crude fiber were relatively low, which may influence its overall nutritional profile and suitability for consumption. Given these findings, further research is recommended to obtain a more comprehensive understanding of heavy metal contamination in suckermouth catfish. Future studies should include an assessment of heavy metal concentrations in industrial and domestic waste sources, as well as an evaluation of potential pathways through which these contaminants enter the waters of Lake Sidenreng. Such investigations would provide valuable insights into the environmental risks associated with heavy metal pollution and contribute to the development of appropriate mitigation strategies to ensure food safety and ecosystem health.

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## Author Contribution
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