



## RESEARCH ARTICLE

# The proximate composition, amino acid profile, fatty acid content, and mineral content of scale flour from three fish species as potential feeds for fish fry [version 1; peer review: awaiting peer review]

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**V1** First published: 13 Sep 2023, 12:1144  
<https://doi.org/10.12688/f1000research.141304.1>  
Latest published: 13 Sep 2023, 12:1144  
<https://doi.org/10.12688/f1000research.141304.1>

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## Abstract

**Background:** Fish scale waste is highly valued both as a food additive and as a functional food ingredient. This study aimed to analyse the chemical composition, fatty acid profile, and mineral content in fish scale flour of *Osphronemus* (O) *goramy*, *Cyprinus* (C) *carpio*, and *Oreochromis* (O) *niloticus* as potential feed for fish fry.

**Methods:** Fish scales were cleaned with 10% w/v NaCl solution at a ratio of 1:10 (w/w) for 24 hours at 4 °C. Agitation was used every eight hours to remove excess protein. Fish scales were evenly arranged in a cooker and cooked at 121 °C for 10 minutes with 15 *psi* pressure. After cooking, 100 grams of wet fish scales was dried at 50 °C for four hours. Dried fish scales were processed into flour for analysis of proximate composition, amino acid content, fatty acid content, and mineral content.

**Results:** The examined fish scale flour from three species displayed significant variations in chemical components, amino acids, and minerals ( $p < 0.01$ ). Crude protein content spanned 49.52% to 72.94%, and fat content ranged from 0.11% to 0.23%. Magnesium levels varied between 767.82 mg/kg and 816.50 mg/kg, calcium content ranged from 3.54 to 12.16 mg/kg, iron content was within 40.46 to 44.10 mg/kg, and zinc content ranged from 45.80 to 139.19 mg/kg. Predominantly, glycine emerged as the main free amino acid (FAA), varying from 13.70% to 16.08%, while histidine had the lowest content, at 0.39% to 0.71%. Conversely, fatty acid content was lowest among the species, ranging from 6.73% to 9.48%.

**Conclusions:** Scale flour from three farmed fish types showed potential for fish fry feed due to its chemical composition and amino

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acid and mineral contents. To enhance the essential fatty acid content, enriching the flour with oils containing eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and  $\alpha$ -linolenic acid (ALA) is essential

### Keywords

Fish scale flour, chemical composition, amino acids, mineral content, fatty acid profile



This article is included in the [Agriculture, Food and Nutrition gateway](#).

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**Competing interests:** No competing interests were disclosed.

**Grant information:** This study was supported by the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia under grant No. 186/E5/PG.02.00. PL/2023 on June 19, 2023.

*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

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**How to cite this article:** Syandri H, Azrita A, Mardiah A *et al.* **The proximate composition, amino acid profile, fatty acid content, and mineral content of scale flour from three fish species as potential feeds for fish fry [version 1; peer review: awaiting peer review]** F1000Research 2023, 12:1144 <https://doi.org/10.12688/f1000research.141304.1>

**First published:** 13 Sep 2023, 12:1144 <https://doi.org/10.12688/f1000research.141304.1>

## Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), global fish production in 2018 reached approximately 179 million tonnes, with aquaculture contributing 46% of the total production.<sup>1</sup> In Indonesia, the total aquaculture production was recorded at 16,032,122 metric tonnes (mt). Of this, 3,374,924 mt (21.05%) originated freshwater aquaculture production; 9,884,670 mt (61.65%) from marine water aquaculture production, including seagrass; and 2,772,568 mt (17.29%) from brackish water aquaculture production (CDSI; Central Data System Information).<sup>2</sup> Approximately 10% of global fish production is currently discarded, while byproducts from fisheries constitute 70% of the total weight of fish production. Among these byproducts, fish bones and scales constitute 14 to 20% of the total weight, and these materials are also discarded.<sup>3</sup>

This significant quantity of byproducts is occasionally utilized as animal feed, fishmeal, oil, or plant fertilizer, but in most instances, it is discarded.<sup>4,5</sup> In recent years, there has been a growing recognition of environmental sustainability and a heightened emphasis on harnessing the value of resources within green and blue economies.<sup>6,7</sup> As a result, fish byproducts, including fish scale waste,<sup>3,8</sup> have gradually been applied as raw materials for human consumption.<sup>9</sup>

Fish scales contain approximately 41-45% organic components, such as collagen, fat, lecithin, sclerotin, and vitamins, and 38-46% inorganic components and mineral elements, including magnesium, iron, zinc, calcium, and vitamins.<sup>10</sup> Furthermore, fish scales possess antioxidant and antihypertensive properties.<sup>11</sup> These components are also crucial for the growth and survival of fish fry. In recent years, fish fry feed has primarily been live feed, and expensive artificial feed is a bottleneck in aquaculture<sup>12,13</sup> Therefore, exploring alternative ingredients for fish fry feed such as fish scale flour is of economic interest.

A significant quantity of fish scale waste is readily accessible in the Indonesian market, encompassing fish scale waste derived from the death of farmed fish in Lake Maninjau.<sup>14</sup> Regrettably, in the past decade, this waste has remained untapped as both a food source and an ingredient for fish fry feed. This research aims to assess the proximate, amino acid, fatty acids and mineral contents in freshwater fish scale flour, specifically flour from the scales of giant gourami (*Osphronemus (O) goramy*), carp (*Cyprinus (C) carpio*), and tilapia (*Oreochromis (O) niloticus*), with the potential to be utilized as feed ingredients for fish fry.

## Methods

### Ethical considerations

The research was approved by the Research and Community Service Ethics Committee at Universitas Bung Hatta with an approval letter No.057a/LPPM/Hatta/VI-2023 dated June 23, 2023. Experiments were carried out in accordance with the guidelines outlined in the Standard Operating Procedure of Laboratory Aquaculture at Universitas Bung Hatta.

### Biometric measurement of fish sample

Ten *O. goramy*, *C. carpio*, and *O. niloticus* fish were obtained from a local fish market in Lake Maninjau, Indonesia. The fresh fish were carefully stored on ice and promptly transported to the laboratory.

Upon reaching the laboratory, the fish were individually weighed (TW) using AD-600i scales with a precision of 0.001 grams and measured to their standard length (SL) and maximum height (H), with distance measured from the mouth to the end of the upper lobe of the caudal fin and height measured vertically, excluding the fins. Standard length and height were assessed using a meter ruler with an accuracy of 1 millimeter. The condition factor (CF) was calculated using the formula  $CF = (TW/SL^3) \times 100$ .

### Preparation of fish scales

Upon arrival at the laboratory, the fish scales from *O. goramy*, *C. carpio*, and *O. niloticus* were collected from each fish for further processing. Fish scales were collected with a stainless steel fish scaler cleaner of 17.5 cm × 3.5 cm × 1.5 cm.

Every 1,000 grams of wet scales of *O. goramy*, *C. carpio*, and *O. niloticus* were washed thoroughly to obtain 200 grams of dry scales. The fish scales were washed in a three-litres plastic jar with 10% w/v NaCl solution with a solution ratio of 1:10 (w/w). The washing procedure was conducted for a duration of 24 hours at a temperature of 4 °C. The washing process was repeated every eight hours to further improve the effectiveness of protein removal. This frequent repetition helped ensure that any remaining unnecessary proteins on the fish scales were thoroughly removed. By repeating the washing process at regular intervals, the purity of the fish scales was enhanced, preparing them for further processing (Figure 1).

Furthermore, scales of *O. goramy*, *C. carpio*, and *O. niloticus* were washed three times in low mineral-content water at room temperature for 10 minutes and then drained. Subsequently, the scales were evenly arranged in a cooker that was



**Figure 1.** Scales of Giant gourami (a), Common carp (b), and Tilapia (c) used in this study.



**Figure 2.** Fish scale flour from Giant gourami (a), Common carp (b), and Tilapia (c) was examined in this study.

equipped with a pressure control button and cooking time settings (Model: Classic Pressure Cooker, with a  $\phi$  20 cm, 5.5-litre capacity, named Culinart, Made in China). The heating process was carried out using a cooker until the temperature reached 121 °C with a pressure of 15 *psi*, as indicated by the temperature and pressure panel. At this point, the timer was set for 10 minutes. The cooking time was calculated as the time between when the pressure in the cooker reached 15 *psi* and that when the heat source for cooking was turned off.

A total of 200 grams of scales from each species (*O. goramy*, *C. carpio*, and *O. niloticus* scales; wet weight) was dried using a 28 L stainless steel black digimatic oven tester at 50 °C for four hours until the moisture content reached 10%. The dried fish scales were then processed into flour using a Miller Powder Grinder with a 100-gram capacity. The resulting flour was then sieved using a mesh size of 60  $\mu$ m to analyse the proximate composition and amino acid, fatty acid, and mineral contents (Figure 2).

#### Proximate and amino acid composition

The proximate composition of the fish scale samples was analysed using standard AOAC methods.<sup>15</sup> The samples were dried at 105 °C until a constant weight was achieved. The crude protein content was analysed using the standard Kjeldahl method, calculated as  $N \times 6.25$ . Crude lipids were analysed using the Soxhlet method with ether extraction. The ash content was determined by incinerating the samples at 550 °C for 16 hours. Gross energy was measured using a bomb calorimeter.

Total carbohydrates were determined by subtracting the sum of % crude protein (CP), % fat (F) and % ash contents (A) from 100<sup>16</sup> by using the following equation: % Total carbohydrates =  $100 - (CP + F + A)$ . The gross energy value of each sample was determined by augmenting the percentage of crude protein (CP), fat (F), and total carbohydrate (C) contents with their respective energy values of 4, 9, and 4 kcal per 100 g of scale flour, respectively, to obtain the caloric values of the samples by using the following equation =  $(4CP + 9F + 4C)$ kcal/100 g weight.

The methods described by Ref. 17 were employed for amino acid analysis. The amino acid composition was determined using a high-performance liquid chromatography (HPLC) system, which consisted of a Waters 1525 binary HPLC pump, 717 autosamplers (Waters®), and Waters 2475 multi  $\lambda$  fluorescence detector optics (with wavelengths set at 250 nm for excitation and 395 nm for emission). The samples were hydrolysed in triplicate using 6 N hydrochloric acid for 24 hours at 11 °C.

#### Mineral content analysis

For the analysis of mineral content (Na, Mg, Ca, K, P, Fe, and Zn), the ashed GCTS sample was dissolved in 1 ml of hydrochloric acid (35% v/v Suprapur® Merck). Subsequently, the sample was filtered using cellulose filter paper

(Watchman No 1, International Ltd; Maidstone, UK) and appropriately diluted for each elemental mineral. Phosphorus (P) levels were analysed using a Perkin-Elmer AA spectrophotometer mod 3110 (Norwalk, CT, USA).

### Fatty acid analysis

The fatty acid composition of fish scale flours was examined through gas chromatography-mass spectrometry (GC-MS) analysis. The total lipid extraction followed a modification of the method by Folch *et al.* (1957), as detailed by Rajion,<sup>18</sup> employing a chloroform: methanol (2.1, v/v) solvent system. Transmethylation was carried out with 14% methanolic boron trifluoride.

### Data analysis

Data analysis was conducted using Statistical Package for the Social Sciences (SPSS) 16.0 software (SPSS; Chicago, IL). The homogeneity of the data was assessed using the Levine test. One-way ANOVA was performed to determine the proximate and amino acid composition parameters and the mineral content for each fish scale flour of the three species. *Post hoc* analysis was carried out using Duncan's multiple-range test.<sup>19</sup> The results are reported as the mean values  $\pm$  standard errors for each parameter.

## Results and discussion

### Biometric measurement

Table 1 displays the average standard length, wet weight, height, condition factor, and chemical composition of three fish species found in Lake Maninjau. Statistically significant variations were noted in the standard length, wet weight, height, and condition factor of the three examined fish species ( $p < 0.05$ ; Table 1).<sup>46</sup>

**Table 1. Biometric, proximate composition and mineral content of scale flour of three fish species.**

	Species			$\alpha$
	<i>O. goramy</i>	<i>C. carpio</i>	<i>O. niloticus</i>	
<i>Biometric measurements</i>				
Wet weight (g)	595.40 $\pm$ 32.31 <sup>a</sup>	633.30 $\pm$ 87 <sup>b</sup>	210.5 $\pm$ 12.12 <sup>c</sup>	***
Standard length (cm)	23.32 $\pm$ 0.62 <sup>a</sup>	26.01 $\pm$ 2.03 <sup>b</sup>	18.0 $\pm$ 0.53 <sup>c</sup>	***
Height (cm)	12.60 $\pm$ 0.36 <sup>a</sup>	9.90 $\pm$ 0.44 <sup>b</sup>	7.15 $\pm$ 0.21 <sup>c</sup>	***
Condition factor	3.91 $\pm$ 0.22 <sup>a</sup>	3.99 $\pm$ 0.65 <sup>b</sup>	3.61 $\pm$ 0.21 <sup>c</sup>	***
<i>Proximate composition</i>				
Moisture % of dry weight	6.74 $\pm$ 0.01 <sup>a</sup>	7.41 $\pm$ 0.03 <sup>b</sup>	5.74 $\pm$ 0.02 <sup>c</sup>	***
Crude protein (%)	56.44 $\pm$ 0.02 <sup>a</sup>	72.94 $\pm$ 0.10 <sup>b</sup>	49.52 $\pm$ 0.01 <sup>c</sup>	***
Fat (%)	0.13 $\pm$ 0.00 <sup>a</sup>	0.23 $\pm$ 0.02 <sup>b</sup>	0.11 $\pm$ 0.00 <sup>c</sup>	***
Ash (%)	32.71 $\pm$ 0.58 <sup>a</sup>	15.45 $\pm$ 0.15 <sup>b</sup>	40.31 $\pm$ 0.03 <sup>c</sup>	***
Fibre (%)	1.22 $\pm$ 0.03 <sup>a</sup>	1.38 $\pm$ 0.01 <sup>b</sup>	1.32 $\pm$ 0.02 <sup>c</sup>	***
Total carbohydrates (%)	11.01 $\pm$ 0.55	11.56 $\pm$ 0.18	10.90 $\pm$ 0.06	ns
Energy value (kkal/100 g DM)	271.05 $\pm$ 2.36 <sup>a</sup>	339.35 $\pm$ 0.50 <sup>b</sup>	239.13 $\pm$ 0.16 <sup>c</sup>	***
<i>Mineral composition</i>				
Macro mineral (mg/kg)				
Sodium (Na)	2,828.13 $\pm$ 0.87 <sup>a</sup>	6,196.65 $\pm$ 0.30 <sup>b</sup>	10,748.66 $\pm$ 0.13 <sup>c</sup>	***
Magnesium (Mg)	816.50 $\pm$ 0.21 <sup>a</sup>	767.82 $\pm$ 0.10 <sup>b</sup>	794.79 $\pm$ 0.20 <sup>c</sup>	***
Calcium (Ca)	10.81 $\pm$ 0.03 <sup>a</sup>	3.54 $\pm$ 0.06 <sup>b</sup>	12.16 $\pm$ 0.03 <sup>c</sup>	***
Potassium (K)	2,111.29 $\pm$ 0.11 <sup>a</sup>	133.88 $\pm$ 0.10 <sup>b</sup>	252.84 $\pm$ 0.10 <sup>c</sup>	***
Phosphorous (P)	6.15 $\pm$ 0.02 <sup>a</sup>	2.74 $\pm$ 0.02 <sup>b</sup>	7.33 $\pm$ 0.05 <sup>c</sup>	***
Microminerals (mg/kg)				
Iron (Fe)	44.10 $\pm$ 0.05 <sup>a</sup>	40.46 $\pm$ 0.09 <sup>b</sup>	41.52 $\pm$ 0.15 <sup>c</sup>	***
Zinc (Zn)	45.80 $\pm$ 0.21 <sup>a</sup>	139.19 $\pm$ 0.05 <sup>b</sup>	55.43 $\pm$ 0.04 <sup>c</sup>	***

Mean  $\pm$  SD (n = 3) with different letters in the same row are significantly different. Level of significance ( $\alpha$ ): \*\*\* $p < 0.001$ ; ns: non-significant.

### Proximate composition and mineral content

In general, there was a significant difference ( $p < 0.05$ ; Table 1) in the proximate content of fish scale flour between the three farmed fish species in Lake Maninjau. The water content, crude protein content, fat content, and energy values were higher in *C. carpio* scale flour than in *O. goramy* and *O. niloticus* scale flours (Table 1).

The highest protein content was recorded in the fish scale flour of *C. carpio*, and the content did not differ by more than 23% between the three fish groups. Huang *et al.*<sup>20</sup> reported that tilapia fish scale flour contained 49.42% protein, 0.02% lipid, 45.18% ash, and 5.38% carbohydrates on a dry weight basis. Similarly, the protein content of spotted golden goatfish (*Parupeneus heptacanthus*) was 45.2%.<sup>21</sup> On the other hand, protein valuation from demineralized fish scale gelatine and nondemineralized gelatine displayed protein purities of 57.19 g/100 g and 43.37 g/100 g, respectively.<sup>3</sup>

Higher fat levels of *C. carpio* scale flour (0.23%) than in *O. goramy* (0.13%) and *O. niloticus* (0.11%) scale flour have also been observed for *Labeo rohita*<sup>22</sup> and other species.<sup>23,24</sup> This result could be due to various factors, including availability and dietary protein intake, fish size and age, and fish scale type.<sup>20,22</sup>

Furthermore, there were significant differences in the mineral content of fish scale flour between species ( $p < 0.05$ ; Table 1). The magnesium, potassium, and iron levels were higher in the *O. goramy* fish scale flour than in the other scale flour samples. At the same time, the sodium, calcium, and phosphorous contents were higher in the *O. niloticus* fish scale flour. Moreover, zinc levels were higher in *C. carpio* fish scale flour (Table 1) than in the other scale flour samples. In general, the levels of the minerals analysed in this study are in alignment with the results of previous studies.<sup>25,26</sup>

The flour derived from fish scales of three farmed fish species exhibited a high mineral content, making it a potentially suitable choice for utilization as feed for fish fry. The inclusion of these minerals in fish feed is crucial because they serve as essential nutrients for the nourishment of fingerlings. As stated by Nagappan *et al.*,<sup>27</sup> fibre, minerals, and vitamins are essential, albeit minimal, requirements for optimal fish growth performance. In the context of fish scale flour, it was observed that all three species contained elevated mineral levels, implying that the scale flour offers enhanced support for the growth of fish fry. Nevertheless, it is important to highlight that despite the relatively high mineral content in the feed, there was no significant impact observed on the development of experimental animals, as noted by Dominquez *et al.*<sup>28</sup> and Wang *et al.*<sup>29</sup>

### Free amino acids (FAAs)

The FAA profiles for the scale flour of the three fish species are presented in Table 2. Statistically significant differences were recorded in the FAA for the scales of the three fish species studied ( $p < 0.05$ ; Table 2). The three species of farmed fish showed higher levels of aspartic acid, glycine, and alanine and lower levels of serine, histidine, methionine, and isoleucine (Table 2). *C. carpio* scale flour showed the highest total FAA content (62.74%) compared to that of farmed fish (*O. goramy*; 48.31% and *O. niloticus*; 41.58%). The differences in the FAA profile could be related to different aspects, such as fish species, wild or farmed fish origin, diet composition, feeding habits, animal size, and age.<sup>30–33</sup>

**Table 2. Profile of free amino acids in scale flours from three fish species (% ww/ww).**

	Scales flour			$\alpha$
	<i>O. goramy</i>	<i>C. carpio</i>	<i>O. niloticus</i>	
Aspartic acid	2.93 ± 0.04 <sup>a</sup>	4.21 ± 0.03 <sup>b</sup>	2.59 ± 0.01 <sup>c</sup>	***
Glutamic acid	6.19 ± 0.01 <sup>a</sup>	8.03 ± 0.01 <sup>b</sup>	5.28 ± 0.01 <sup>c</sup>	***
Serine	1.91 ± 0.01 <sup>a</sup>	2.85 ± 0.01 <sup>a</sup>	1.76 ± 0.01	***
Glycine	16.08 ± 0.01 <sup>a</sup>	19.08 ± 0.01 <sup>b</sup>	13.70 ± 0.01 <sup>c</sup>	***
Histidine	0.39 ± 0.01 <sup>a</sup>	0.71 ± 0.01 <sup>b</sup>	0.42 ± 0.01 <sup>c</sup>	***
Arginine	3.67 ± 0.01 <sup>a</sup>	5.15 ± 0.01 <sup>b</sup>	3.19 ± 0.01 <sup>c</sup>	***
Threonine	1.50 ± 0.03 <sup>a</sup>	2.04 ± 0.01 <sup>b</sup>	1.34 ± 0.01 <sup>c</sup>	***
Alanine	6.06 ± 0.01 <sup>a</sup>	6.97 ± 0.00 <sup>b</sup>	5.01 ± 0.01 <sup>c</sup>	***
Tyrosine	1.79 ± 0.01 <sup>a</sup>	2.29 ± 0.01 <sup>b</sup>	1.51 ± 0.01 <sup>c</sup>	***
Valine	1.53 ± 0.00 <sup>a</sup>	1.89 ± 0.01 <sup>b</sup>	1.24 ± 0.01 <sup>c</sup>	***
Methionine	0.37 ± 0.01 <sup>a</sup>	1.45 ± 0.01 <sup>b</sup>	0.50 ± 0.02 <sup>c</sup>	***



**Table 2.** Continued

	Scales flour			$\alpha$
	<i>O. goramy</i>	<i>C. carpio</i>	<i>O. niloticus</i>	
Isoleucine	0.91 ± 0.01 <sup>a</sup>	1.46 ± 0.00 <sup>b</sup>	0.76 ± 0.01 <sup>c</sup>	***
Leucine	0.90 ± 0.01 <sup>a</sup>	2.34 ± 0.01 <sup>b</sup>	1.46 ± 0.01 <sup>c</sup>	***
Phenylalanine	1.34 ± 0.01 <sup>a</sup>	1.99 ± 0.01 <sup>b</sup>	1.23 ± 0.01 <sup>c</sup>	***
Lysine	2.03 ± 0.01 <sup>a</sup>	2.30 ± 0.01 <sup>b</sup>	1.57 ± 0.01 <sup>c</sup>	***
Total	48.31	62.74	41.58	

Mean ± SD (n = 3) with different letters in the same row are significantly different.  
Level of significance ( $\alpha$ ): \*\*\*p < 0.001.

In all samples, glycine was the most abundant FAA, which is in accordance with other studies on fish scale collagen in tilapia, *Oreochromis* sp.,<sup>20</sup> and the whole-body carcass of *Hemibagrus nemurus*<sup>34</sup> and *O. goramy*.<sup>35</sup> Glycine has been reported to be one of the essential components in the collagen molecule, helping maintain tissue strength and elasticity.<sup>36,37</sup>

Following glycine, the most abundant FAAs were glutamic acid, alanine, and arginine. Furthermore, histidine, methionine, and isoleucine were present in all samples but in smaller quantities; these particular FAA are commonly found in greater proportions within aquatic organisms.<sup>38,39</sup>

### Fatty acid profile

The fatty acid composition in the fish scale flour of the three cultivated fish species is displayed in Table 3. This discovery is in line with data previously reported for Atlantic salmon (*salmo salar*) and Catla catla (*Labeo catla*),<sup>40,41</sup> where the fatty acid content of both species is relatively low. Variations in the fatty acid composition were evident among the three cultured fish species, with statistically significant differences (p < 0.05) observed among the species. Nevertheless, only two out of the fourteen saturated fatty acids (SAFAs) were identified. In monounsaturated fatty acids (MUFAs), three out of eight were observed, whereas three of the ten polyunsaturated fatty acids (PUFAs) were found. This result is in contrast to the type of fatty acids detected in the carcasses of several species of fish.<sup>42–45</sup>

**Table 3.** Fatty acids concentrations of scale flours from three fish species (%w/w).

	Fish scales flour			
	<i>O. goramy</i>	<i>C. carpio</i>	<i>O. niloticus</i>	$\alpha$
<i>Saturated fatty acids (SAFAs)</i>				
Butyric Acid, C4:0	0.00	0.00	0.00	
Caproic acid, C6:0	0.00	0.00	0.00	
Caprilic acid, C8:0	0.00	0.00	0.00	
Capric acid, C10:0	0.00	0.00	0.00	
Undecanoic acid, C11:0	0.85 ± 0.01 <sup>a</sup>	0.58 ± 0.01 <sup>b</sup>	0.72 ± 0.01 <sup>c</sup>	***
Lauric Acid, C12:0	0.00	0.00	0.00	
Tridecanoic Acid, C13:0	0.40 ± 0.01 <sup>a</sup>	0.36 ± 0.01 <sup>b</sup>	0.17 ± 0.01 <sup>c</sup>	***
Myristic Acid, C14:0	0.00	0.00	0.00	
Pentadecanoic Acid, C15:0	0.00	0.00	0.00	
Palmitic Acid, C16:0	0.00	0.00	0.00	
Heptadecanoic Acid, C17:0	0.00	0.00	0.00	
Stearic Acid, C18:0	0.00	0.00	0.00	
Arachidic Acid, C20:0	0.00	0.00	0.00	
Behenic Acid, C22:0	0.00	0.00	0.00	
Total SAFAs	1.25	0.94	0.89	

**Table 3.** Continued

	Fish scales flour			
	<i>O. goramy</i>	<i>C. carpio</i>	<i>O. niloticus</i>	$\alpha$
<i>Monounsaturated fatty acids (MUFAs)</i>				
Myristoleic Acid, C14:1	0.00	0.00	0.00	
Cis-10-Pentadecanoic Acid, C15:1	2.02 ± 0.01 <sup>a</sup>	2.01 ± 0.01 <sup>b</sup>	2.26 ± 0.01 <sup>c</sup>	***
Palmitoleic Acid, C16:1	0.00	0.00	0.00	
Cis-10-Heptadecanoic Acid, C17:1	0.73 ± 0.01 <sup>a</sup>	1.21 ± 0.01 <sup>b</sup>	1.19 ± 0.01 <sup>c</sup>	***
Elaidic Acid, C18:1n9t	2.09 ± 0.01 <sup>a</sup>	2.28 ± 0.01 <sup>b</sup>	3.71 ± 0.02 <sup>c</sup>	***
Oleic Acid, C18:1n9c	0.00	0.00	0.00	
Erucic Acid Methyl Ester, C22:1n9	0.00	0.00	0.00	
Nervonic Acid, C24:1	0.00	0.00	0.00	
Total MUFAs	4.84	5.50	7.16	
<i>Polyunsaturated fatty acids (PUFAs)</i>				
Linolelaidic Acid, C18:2n9	0.00	0.00	0.00	
Linoleic Acid, C18:2n6c	0.15 ± 0.01 <sup>a</sup>	0.12 ± 0.01 <sup>b</sup>	0.17 ± 0.01 <sup>c</sup>	***
$\nu$ -Linolenic Acid, C18:3n6	0.22 ± 0.00 <sup>a</sup>	0.28 ± 0.01 <sup>b</sup>	0.40 ± 0.01 <sup>c</sup>	***
Linolenic Acid, C18:3n3	0.00	0.00	0.00	
Cis-8,11,14-Eicosatrienoic Acid, C20:3n6	0.00	0.00	0.00	
cis-11, 14, 17-Eicosatrienoic Acid Methyl Ester, (C20:3n3)	0.00	0.00	0.00	
Arachidonic Acid, C20:4n6	0.00	0.00	0.00	
Cis-13,16-Docosadienoic Acid, C22:2	0.00	0.00	0.00	
Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3	0.27 ± 0.01 <sup>a</sup>	0.48 ± 0.01 <sup>b</sup>	0.86 ± 0.01 <sup>c</sup>	***
Cis-4,7,10,13,16,19-Docosahexaenoic Acid, C22:6n3	0.00	0.00	0.00	
Total PUFAs	0.64	0.88	1.43	
$\Sigma$ Fatty acid	6.73	7.32	9.48	

Mean  $\pm$  SD (n = 3) with different letters in the same row are significantly different. Level of significance ( $\alpha$ ): \*\*\*p < 0.001.

Fish scale flour from *O. niloticus* exhibited the highest cumulative fatty acid content (9.48%) in comparison to farmed fish scale flour (*C. carpio*; 7.32% and *O. goramy*; 6.73%). These findings are very similar in structure to the results obtained from analysis of the composition of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) in the whole-body carcass of giant gourami and other fish species.<sup>30,32,43</sup>

Based on the analysis of the composition of the fatty acids contained in the scale flour of three species of farmed fish, if it is intended as feed for fish fry, it is necessary to enrich this fish scale flour with compounds containing fatty acids. Some enrichment options to consider are fish oil, chia seed oil, flaxseed oil, and walnut oil. These four sources are rich in omega-3 fatty acids, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), as well as alpha-linolenic acid (ALA).

## Conclusion

Fish scale flour derived from *O. goramy*, *C. carpio*, and *O. niloticus* in the study region was identified as a valuable protein, amino acid, and mineral source. All fish scale flour samples across the three species contained amino acids and minerals but not fatty acids. Consequently, enriching fish scale flour with animal and plant oils rich in omega-3 fatty acids is vital. There is a lack of reliable data regarding the chemical composition, mineral, and fatty acid profiles of fish scale flours from the three local fish species in the study area. Therefore, the chemical, mineral, and fatty acid composition data presented in this study will be the groundwork for future research in fish scale flour chemistry, contributing to fish fry nutrition optimization.



## Data availability

### Underlying data

Figshare: The Proximate Composition, Amino Acid Profile, Fatty Acid Content, and Mineral Content of Scale Flour from Three Fish Species as Potential Feeds for Fish Fry, <https://doi.org/10.6084/m9.figshare.23954799>.<sup>46</sup>

This project contains the following underlying data:

- Table 1. Raw biometric data of three species of farmed fish samples.
- Table 2. Raw proximate composition data of fish scale flour from three Species (%W/W).
- Table 3. Raw mineral content data of fish scale flour from three Species (mg/kg).
- Table 4. Raw Amino Acid Composition Data of Fish Scale Flour from Three Species (%W/W).
- Table 5. Raw fatty Acid Composition Data of Fish Scale Flour from Three Species (%W/W).

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/) (CC-BY 4.0).

## Acknowledgements

We extend our gratitude to the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for supporting this research.

## References

1. FAO: *The state of world fisheries and Aquaculture*. Rome, Italy: Food and Agriculture Organization of the United Nations; 2020.
2. CDSI: (Central Data System Information): Ministry of Marine and Fisheries Republic of Indonesia. (In Indonesian), 2018.
3. Boronat O, Sintes P, Celis F, et al.: **Development of added-value culinary ingredients from fish waste: Fish bones and fish scales**. *Int. J. Gastron. Food Sci.* 2023; **31**: 100657. [Publisher Full Text](#)
4. Gehring CK, Gigliotti JC, Moritz JS, et al.: **Functional and nutritional characteristics of proteins and lipids recovered by isoelectric processing of fish by-products and low-value fish: A review**. *Food Chem.* 2011; **124**(2): 422–431. [Publisher Full Text](#)
5. Gilman E, Roda AP, Huntington T, et al.: **Benchmarking global fisheries discards**. *Sci. Rep.* 2020; **10**: 14017. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
6. Kratky L, Zamazal P: **Economic feasibility and sensitivity analysis of fish waste processing biorefinery**. *J. Clean. Prod.* 2020; **243**: 118677. [Publisher Full Text](#)
7. Venugopal V: **Green processing of seafood waste biomass towards blue economy**. *CRSUST.* 2022; **4**: 100164. [Publisher Full Text](#)
8. Silva AVS, Torquato LDM, Cruz G: **Potential application of fish scales as feedstock in thermochemical processes for the clean energy generation**. *Waste Manag.* 2019; **100**: 91–100. [PubMed Abstract](#) | [Publisher Full Text](#)
9. Islam J, Yap EES, Krongpong L, et al.: *Fish Waste Management – an Assessment of the Potential Production and Utilization of Fish Silage in Bangladesh, Philippines and Thailand*. FAO Fisheries and Aquaculture Circular; 2021; vol. 1216: 2021.
10. Lou L, Zhou Z, You X, et al.: **Mineral-chelating peptides derived from fish collagen: Preparation, bioactivity and bioavailability**. *LWT.* 2020; **134**: 110209. [Publisher Full Text](#)
11. El-Rashidy AA, Gad AY, El-Hay A, et al.: **Chemical and biological evaluation of Egyptian Nile Tilapia (*Oreochromis niloticus*) fish scale collagen**. *Int. J. Biol. Macromol.* 2015; **79**: 618–626. [PubMed Abstract](#) | [Publisher Full Text](#)
12. Lahnsteiner F, Lahnsteiner E, Duenser A: **Suitability of Different Live Feed for First Feeding of Freshwater Fish Larvae**. *Aquac. J.* 2023; **3**(2): 107–120. [Publisher Full Text](#)
13. Syandri H, Azrita A, Thamrin R, et al.: **Broodstock development, induced spawning and larval rearing of the bilih, *Mystacoleucus padangensis* (Bleeker, 1852), a vulnerable species, and its potential as a new aquaculture candidate**. *F1000Res.* 2023; **12**: 420. [Publisher Full Text](#)
14. Syandri H, Azrita, Junaidi, et al.: **Levels of available nitrogen-phosphorus before and after fish mass mortality in Maninjau Lake of Indonesia**. *J. Fish. Aquat. Sci.* 2017; **12**(4): 191–196. [Publisher Full Text](#)
15. AOAC: *Official Methods of Analysis*. 15th ed. Washington, DC, USA: Association of Official Analytical Chemists (AOAC); 1990.
16. Onyeike EN, Ayoologu EO, Ibegbulam CO: **Evaluation of the nutritional value of some crude oil in polluted freshwater fish**. *Global J. Pure Appl. Sci.* 2000; **6**: 227–233. [Publisher Full Text](#)
17. Cohen SA: *Amino acid analysis using pre-column derivatization with 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate. Protein Sequencing Protocols*. Smith BJ, editor. 2nd Edn. Totowa, NJ: Humana Press Inc.; 2003; vol. **211**: pp. 143–154. 9781592593422.
18. Rajion MA: **Essential fatty acid metabolism in the fetal and neonatal lamb**. PhD. Thesis. The University of Melbourne Australia. 1985.
19. Duncan DB: **Multiple ranges and multiple F tests**. *Biometrics.* 1955; **11**: 1–42. [Publisher Full Text](#)
20. Huang CY, Kuo JM, Wu SJ, et al.: **Isolation and characterization of fish scale collagen from tilapia (*Oreochromis* sp.) by a novel extrusion-hydro-extraction process**. *Food Chem.* 2016; **190**: 997–1006. [PubMed Abstract](#) | [Publisher Full Text](#)
21. Matmaroh K, Benjakul S, Prodoran T, et al.: **Characteristics of acid soluble collagen and pepsin soluble collagen from scale of spotted golden goatfish (*Parupeneus heptacanthus*)**. *Food Chem.* 2011; **129**(3): 1179–1186. [PubMed Abstract](#) | [Publisher Full Text](#)

22. Begum M, Mun MZUAM, Mas M: **Nutritional profiling of selected fish's scales: An approach to determine its prospective use as a biomaterial.** *Int. J. Fish. Aquat. Sci.* 2021; **9**(3): 26–31.
23. Chinh NT, Manh VQ, Trung VQ, *et al.*: **Characterization of collagen derived from tropical freshwater Carp fish scale wastes and its amino acid sequence.** *Nat. Prod. Commun.* 2019; **14**: 1934578X1986628–1934578X1986612.  
[Publisher Full Text](#)
24. Gil-Duran S, Arola D, Ossa EA, *et al.*: **Effect of chemical composition and microstructure on the mechanical behavior of fish scales from *Megalops Atlanticus*.** *ScienceDirect.* 2016; **56**: 134–145.  
[Publisher Full Text](#)
25. Maktoof A, Elherarlla RJ, Ethaib S: **Identifying the nutritional composition of fish waste, bones, scales, and fins.** *IOP Conf. Ser.: Mater. Sci.* 2020; **871**: 012013.  
[Publisher Full Text](#)
26. Sukma, Andi M, Pamungkas BF, *et al.*: **Proximate composition and mineral profile of bone and scale of Papuyu Fish (*Anabas testudineus*).** *Media Teknologi Hasil Perikanan.* 2022; **10**(3): 185–191. Abstract|
27. Nagappan S, Das P, Quadir MA, *et al.*: **Potential of microalgae as a sustainable feed ingredient for aquaculture.** *J. Biotechnol.* 2021; **341**: 1–20.  
[PubMed Abstract](#) | [Publisher Full Text](#)
28. Dominiquez D, Sehnine CP, *et al.*: **Dietary manganese levels for gilthead sea bream (*Sparus aurata*) fingerlings fed diets high in plant ingredients.** *Aquaculture.* 2020; **529**: 735614.  
[Publisher Full Text](#)
29. Wang L, Sagada G, Wang R, *et al.*: **Different forms of selenium supplementation in fish feed: The bioavailability, nutritional functions, and potential toxicity.** *Aquaculture.* 2022; **549**: 737819.  
[Publisher Full Text](#)
30. Jabeen F, Chaudhry AS: **Chemical compositions and fatty acid profiles of three freshwater fish species.** *Food Chem.* 2011; **125**(3): 991–996.  
[Publisher Full Text](#)
31. Fuentes A, Fernández-Segovia I, Serra JA, *et al.*: **Comparison of wild and cultured sea bass (*Dicentrarchus labrax*) quality.** *Food Chem.* 2010; **119**: 1514–1518.  
[Publisher Full Text](#)
32. Azrita A, Syandri H, Aryani N, *et al.*: **The utilization of new products formulated from water coconut, palm sap sugar, and fungus to increase nutritional feed quality, feed efficiency, growth, and carcass of gurami sago (*Osphronemus goramy* Lacepède, 1801) juvenile.** *F1000Res.* 2021; **10**: 1121.  
[Publisher Full Text](#)
33. Kasozi N, Iwe G, Sadik K, *et al.*: **Dietary amino acid requirements of pebbly fish, *Alestes baremoze* (Joannis, 1835) based on whole body amino acid composition.** *Aquac. Rep.* 2019; **14**: 100197.  
[Publisher Full Text](#)
34. Hasan B, Putra I, Suharman I, *et al.*: **Growth performance and carcass quality of river catfish, *Hemibagrus nemurus* fed salted trash fish meal.** *Egypt. J. Aquat. Res.* 2019; **45**(3): 259–264.  
[Publisher Full Text](#)
35. Azrita A, Syandri H, Aryani N, *et al.*: **Effect of feed enriched by products formulated from coconut water, palm sap sugar, and mushroom on the chemical composition of feed and carcass, growth performance, body indices, and gut micromorphology of giant gourami, *Osphronemus goramy* (Lacepède, 1801), juveniles.** *F1000Res.* 2023; **12**: 140.  
[Publisher Full Text](#)
36. Johnson AA, Cuellar TL: **Glycine and aging: Evidence and mechanisms.** *Ageing Res. Rev.* 2023; **87**: 101922.  
[PubMed Abstract](#) | [Publisher Full Text](#)
37. Li C, Dai H, Wang Q, *et al.*: **Recent progress in preventive effect of collagen peptides on photoaging skin and action mechanism.** *Food Sci. Human Wellness.* 2022; **11**(2): 218–229.  
[Publisher Full Text](#)
38. McLean E, Alfrey KB, Gatlin DM III, *et al.*: **Muscle amino acid profiles of eleven species of aquacultured animals and their potential value in feed formulation.** *Aquac. Fish.* 2022.  
[Publisher Full Text](#)
39. Vijayaram S, Ringø E, Zuurro A, *et al.*: **Beneficial roles of nutrients as immunostimulants in aquaculture: A review.** *Aquac. Fish.* 2023.  
[Publisher Full Text](#)
40. Grah-Nielsen O, Clover KA: **Fatty acids in fish scales.** *Mar. Biol.* 2010; **157**: 1567–1576.  
[Publisher Full Text](#)
41. Prabu K, Shankarlal S, Natarajan E: **Fatty acid profile of fish scale of *Catla catla*.** *AJB.* 2015; **14**(21): 1828–1831.  
[Publisher Full Text](#)
42. Chen C, Guan W, Xie Q, *et al.*: **n-3 essential fatty acids in Nile tilapia, *Oreochromis niloticus*: Bioconverting LNA to DHA is relatively efficient and the LC-PUFA biosynthetic pathway is substrate limited in juvenile fish.** *Aquaculture.* 2018; **495**: 513–522.  
[Publisher Full Text](#)
43. Aryani N, Suharman I, Hasibuan S, *et al.*: **Fatty acid composition on diet and carcasses, growth, body indices and profile serum of Asian redtail catfish (*Hemibagrus nemurus*) fed a diet containing different levels of EPA and DHA.** *F1000Res.* 2023; **11**: 1409  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
44. Qian C, Hart B, Colombo SM: **Re-evaluating the dietary requirement of EPA and DHA for Atlantic salmon in freshwater.** *Aquaculture.* 2020; **518**: 734870.  
[Publisher Full Text](#)
45. Mohanty BP, Mahanty A, Ganguly, *et al.*: **Nutritional composition of food fishes and their importance and providing food and nutritional security.** *Food Chem.* 2019; **293**: 561–570.  
[PubMed Abstract](#) | [Publisher Full Text](#)
46. Syandri H: **The Proximate Composition, Amino Acid Profile, Fatty Acid Content, and Mineral Content of Scale Flour from Three Fish Species as Potential Feeds for Fish Fry.** [Dataset]. *figshare.* 2023.  
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