RESEARCH ARTICLE

Production and characteristics of sailfin catfish (*Pterygoplichthys pardalis*) protein hydrolysate [version 1; peer review: 2 not approved]

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Abstract

Background: The sailfin catfish (*Pterygoplichthys pardalis*) is a freshwater fish from the Loricariidae family, and is considered an invasive species in Indonesia. The fish is usually neglected and discarded. Its protein hydrolysate is the product of the breakdown of proteins into amino acids through the hydrolysis of acids, bases, or enzymes. Therefore, this study aims to determine the hydrolysate characteristics of sailfin catfish (*Pterygoplichthys pardalis*) proteins, produced with different pH and hydrolysis durations.

Methods: The hydrolysis was carried out with variable pH (control, 5, 7, 9) and hydrolysis durations (12 and 24 hours) in three replicates.

Results: The hydrolysis duration, pH, and interaction of both variables had significant effects ($p < 0.05$) on the parameters of yield, antioxidant activity, degree of hydrolysis, protein levels, and ash content. Similarly, the moisture content, hydrolysis duration, and pH were significantly affected ($p < 0.05$), while their interactions were not ($p > 0.05$).

The pH treatment had a significant effect on fat content ($p < 0.05$), while the hydrolysis length and the interaction between the two had no significant effect ($p > 0.05$). Based on this study, the best resulting production of fish protein hydrolysate (FPH) from sailfin catfish were a for a combination of pH 9 and a hydrolysis duration of 24 hours. The characteristics of FPH produced were as follows: a yield of 57.39%, antioxidant activity 63.99%, degree of hydrolysis 40.67%, water content 7.28%, ash content 7.63%, fat content 5.10%, protein content 34.51%, molecular weight 6.14 -118.17 KDa, total essential amino acids 49.30%, and nonessential amino acids 50.71%.

Conclusions: Two factors affected FPH characteristics in sailfin catfish (*Pterygoplichthys pardalis*). The best processing conditions to obtain optimal characteristics for FPH were a yield of 57.39%, antioxidant levels of 63.99%, a DH of 40.67%, a moisture content of 7.28%, ash content of 7.63%, fat content of 5.10%, and protein content of 34.51%.

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Keywords

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Introduction

The sailfin catfish (*Pterygoplichthys pardalis*) is a freshwater fish from the Loricariidae family and native to the Americas (Susanto, 2014). In Indonesia, sailfin catfish are present in various locations with high levels of pollution (Qoyyimah *et al.*, 2016), and have a negative impact because they prey on other species. The fish can dominate the water and become a predator or competitor of domestic fish (Hadiaty, 2011). Sailfin catfish is considered as an under exploited fish (Guo *et al.*, 2019). Despite being discarded as bycatch, the nutritional content of sailfin catfish is relatively high, especially the protein, fat, and carbohydrates contents (Panase *et al.*, 2018). Hence, the use of proteins in less valuable fish species can increase the functional value of the product (Hsu, 2010). The production of fish protein hydrolysate (FPH) is considered the most important source of protein and bioactive peptides (Chalamaiah *et al.*, 2012).

FPH is a product of the decomposition of fish proteins into smaller fragments of peptides that contain between two and 20 amino acids through hydrolysis by enzymes, acids, or bases (Latifah, 2013; Chalamaiah *et al.*, 2012). FPH is produced mainly through protease activity controlled by additional enzymes or endogenous protease enzymes from raw materials (Swanepoel and Goosen, 2018).

Previous studies on the production of FPH using endogenous enzymes have been carried out on Alaska pollack (Je *et al.*, 2005), ornate threadfin bream (Nalinanon *et al.*, 2011), barramundi fish, silver warehou fish, salmon (Nurdiani *et al.*, 2015), and parrotfish (*Chlorurus sordidus*) (Prihanto *et al.*, 2019). During the production process, precise hydrolysis conditions such as temperature, pH, and hydrolysis duration need to be considered to achieve optimal results (Meldstad, 2015). Therefore, this study aims to determine the optimum conditions for the production of FPH from the sailfin catfish (*Pterygoplichthys pardalis*) protein and characterize its product.

Methods

Materials

Sailfin catfish (*Pterygoplichthys pardalis*); methanol; 2,2-diphenyl-1-picrylhydrazyl, alcohol (DPPH); ascorbic acid; TCA 20%; H₂SO₄; NaOH; methyl orange; borax; HCL 0.01 N; petroleum ether; tris base; HCl 6 N; dH₂O; acrylamide; N,N'-bis-methylene-acrylamide; glycine; SDS; APS; TEMED; glacial acetic acid and Coomassie Brilliant Blue G-250 (All chemicals and reagents were analytical grade and purchased from Merck, Germany).

Sample collection

About 5 kg of Sailfin catfish (*Pterygoplichthys pardalis*) were collected from the river in Blitar Regency, East Java, Indonesia. The sailfin catfish were washed with water to remove dirt and brought to the laboratory in a cool box at a temperature of 4°C.

Fish protein hydrolysate process

A preliminary study was conducted to determine the best comparison of sample and Aqua Dest (w/v) for the production of FPH. At this stage, a whole sailfin catfish (*Pterygoplichthys pardalis*) was chopped and smoothed using a Philips food processor (model HR7627, 650 W), and the chopped fish (20 grams) was added to Aqua Dest distilled water with a ratio of sample to Aqua Dest as follows 1:0, 1:1, 1:2, and 3 (w/v). The hydrolysis process was carried out for 18 hours using a shaker at 150 rpm and a temperature of 30 ± 2°C. Furthermore, the FPH was centrifuged at 3000 rpm for 30 minutes and the ratio with the highest yield was used for the subsequent investigation.

The main study was carried out to determine the characteristics of sailfin catfish FPH, and the investigated factors were variations in pH and duration of hydrolysis. The pH levels used were 5, 7, 9, and 6.4 (control) with 12 and 24 hours of hydrolysis, while in the sample comparison, 1:2 (w/v) Aqua Dest was used. Meanwhile, the hydrolysis process was carried out following the same procedure as the preliminary study, and the supernatant obtained was dried using a spray drying method (Prihanto *et al.*, 2019).

Yield

The FPH yield was calculated from the percentage of the number of hydrolysate products obtained against the volume of initial raw materials as of the hydrolysis process. The yield was calculated using the following formula:

$$\text{Yield} = \frac{\text{final weight}}{\text{initial weight}} \times 100\%$$

Antioxidant levels

The inhibitory effect of DPPH free radicals was determined according to the method by Donkor *et al.* (2012), with a slight adjustment on the wavelength used. The inhibitory effect of DPPH free radicals was determined according to the method

by [Donkor *et al.* \(2012\)](#), with slight modifications on wavelength, where they originally used 515 nm. Briefly, a dissolved protein fraction (100 µL) was added to the 3900 µL solution of DPPH 0.075 mM in methanol. In a dark room, an aliquot was homogenized and incubated for 30 minutes at room temperature (28 ± 2 °C). A UV-Vis spectrophotometer (Genesys 6, Thermofisher Scientific, USA) was used to measure the absorbance of the aliquot at a wavelength of 517 nm. The antioxidant activity was based on the equation below:

$$\% \text{ inhibition} = \frac{A - B}{A} \times 100\%$$

A = Blank absorbance

B = Sample absorbance

Degree of hydrolysis

The degree of dissolved protein hydrolysis in the production of fish protein hydrolysate was calculated according to the method by [Hoyle and Merritt \(1994\)](#). The dissolved protein fraction (2 mL) was added to 2 mL of 20% TCA and the solution was centrifuged at a speed of 5000 rpm for 10 minutes at room temperature. Furthermore, the supernatant was taken to determine the nitrogen content after adding a 20% TCA solvent using the Kjeldahl method ([AOAC, 2005](#)). The degree of hydrolysis (DH) was defined by the following equation:

$$\% \text{ DH} = \frac{\text{Total N on TCA } 20\%}{\text{Total N on sample}} \times 100\%$$

Proximate analysis

The analysis of FPH proximal was carried out using standard methods from [AOAC \(2005\)](#). Protein levels were determined using the Kjeldahl method, while fat content was determined using the Soxhlet method. Furthermore, the water content analysis was conducted using the drying method, in an oven at a temperature of 105°C for 2 hours. The ash levels were also determined using the drying method in the furnace at 550°C, for at least five hours until the stable weight was achieved.

Molecular weight (SDS-PAGE analysis)

An SDS-PAGE analysis was carried out based on the Laemli (1970) method. A sample of 15 µL was mixed with a 15 µL sample buffer and heated at 100°C for 15 minutes. The SDS-PAGE analysis used a 12% gel-separating concentrate and a 4% gel stacking, and the running process was started at a constant current of 20 mA 100 V for three hours. Meanwhile, staining was carried out by soaking the gel in a staining solution which contained one gram of Coomassie Brilliant Blue G-250 (Merck, Catalogue No. 1154440025), 450 mL of methanol, 100 mL of glacial acetic acid, and 450 mL of Aqua Dest. The molecular weight calculations were analyzed by comparing the bands appearing on the samples with the standard markers.

Amino acids analysis

The amino acid content was analyzed based on [Boogers *et al.* \(2008\)](#), using the ultra-performance liquid chromatography (UPLC) method. Moreover, the sample liquid (0.50 mL) was added to 2.0 mL of AABA's standard internal solution of 10 mM, diluted with HCl 0.1 N, and homogenized. The solution was filtered using a filter membrane of 0.22 µm, and 10 µL of the solution were taken and placed in a vial. The aliquot was added to 70 µL AccQ-fluor borate and vortexed. Similarly, approximately 20 µL of the reagent fluor A was added and vortexed. The solution was allowed to stand for a minute and further incubated for 10 minutes at a temperature of 55°C, and the sample was later injected into the UPLC system.

Statistics

The experiment was optimized using the response surface method (RSM), which was presented in a contour plot using the Minitab 18 software tool (Minitab Pty Ltd., Sydney, NSW, Australia). Apart from optimization, all the data obtained were analyzed with the one-way variant analysis, followed by a post-hoc test. Furthermore, all data were analyzed in triplicate, and the results are presented as the mean $\pm$ SD.

Results

Proximate content of raw material

The proximate content of sailfin catfish (*Pterygoplichthys pardalis*) is shown in [Table 1](#). Based on the results, the sailfin catfish protein content was 30.42%, while the fat content was 5.24%.

Table 1. Proximate composition of sailfin catfish.

Proximate composition	sailfin catfish*	sailfin catfish**
Moisture Content (%)	59,14	77,5
Protein (%)	30,42	19,74
Fat (%)	5,24	1,73
Ash (%)	3,36	1,01
Carbohydrate (%)	0,62	-

Source: *This study.

**Munandar and Eurika (2016).

Figure 1. Fraction layer of sailfin catfish hydrolysate.

Yield and antioxidant activity

After the centrifugation process, the sample formed five layers of different fractions. These layers included the oil, the light lipoprotein, the dissolved protein (liquid/soluble protein), the fine particles, and the rough particles at the bottom of the cuvette, as shown in Figure 1. The different sample and Aqua Dest ratios affected FPH production yields and antioxidants ($P < 0.05$). Meanwhile, the highest yield and antioxidants were obtained for a sample and Aqua Dest ratio of 1:2 (w/v) (Figure 2), with a soluble protein yield of $78.25 \pm 1.75\%$ and antioxidant levels of $46.70 \pm 0.30\%$. These samples with an Aqua Dest ratio of 1:2 (w/v) were used to manufacture FPH in the advanced study and analyzed to determine the characteristics of FPH.

Yield

The hydrolysis duration and pH had a significant effect on the yield of FPH, which ranged from $20.29 \pm 0.27\%$ to $57.39 \pm 0.17\%$ (Table 2). The highest yield value ($57.39 \pm 0.17\%$) was obtained at pH 9 and after a 24-hour hydrolysis duration, while the lowest value was obtained in control treatment after a 12-hour hydrolysis duration, with a value of $20.29 \pm 0.27\%$.

Antioxidant activity

The results showed that the antioxidant values of FPH ranged from $11.56 \pm 1.59\%$ to $63.99 \pm 0.62\%$ (Table 2). Furthermore, there was a significant difference ($P < 0.05$) in antioxidant activity with variations in pH and duration of

Figure 2. Yield and antioxidant of the FPH from sailfin catfish.

hydrolysis. The highest antioxidant activity of $63.99 \pm 0.62\%$ was obtained at pH 9 with a 24-hour hydrolysis, while the lowest value (of $11.56 \pm 1.59\%$) was obtained for the control treatment with a 12-hour hydrolysis.

Degree of hydrolysis (DH)

The duration of hydrolysis and pH significantly affected the DH ($P < 0.05$). Based on the results, the DH of the fish protein hydrolysis samples ranged from $22.08 \pm 1.77\%$ to $40.67 \pm 1.19\%$. The highest DH ($40.67 \pm 1.19\%$) was obtained at pH 9 after a 24-hour hydrolysis duration, while the lowest value was obtained for pH 5 after 12 hours ($22.08 \pm 1.77\%$).

Proximate analysis

Based on the approximate FPH content as shown in Table 2, the hydrolysis duration, pH, and interaction between both factors gave significantly different protein content results ($P < 0.05$), which ranged from $8.51 \pm 1.34\%$ to $34.51 \pm 1.56\%$. Furthermore, the highest protein content ($34.51 \pm 1.56\%$) was obtained at pH 9 for a 24-hour hydrolysis duration.

Different pH treatments gave significantly different results ($P < 0.05$), while the duration of hydrolysis and the interaction of both factors had no significant impact ($P > 0.05$) on fat levels. Meanwhile, fat content ranged from $4.37 \pm 0.22\%$ to $5.30 \pm 0.13\%$. The fat content in the study decreased compared to the content of the raw materials of sailfin fish due to the separation of fat and lipoproteins during centrifugation, while some lipids still existed in the hydrolysate.

The results showed that the moisture content of the FPH ranged from $7.28 \pm 1.06\%$ to $13.84 \pm 0.36\%$. Additionally, hydrolysis duration and pH variations gave significantly different results ($P < 0.05$), while the interaction of these

Table 2. Characteristics of FPH from sailfin catfish.

Parameters	Control		pH 5		pH 7		pH 9	
	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h
Yield	20.29 ± 0.27 ^e	22.52 ± 0.69 ^e	42.44 ± 0.64 ^d	50.15 ± 1.28 ^b	45.95 ± 0.28 ^c	50.77 ± 1.10 ^b	47.21 ± 1.08 ^c	57.39 ± 0.17 ^a
Antioxidants	11.56 ± 1.59 ^f	14.74 ± 0.94 ^e	24.58 ± 0.88 ^d	48.36 ± 1.42 ^b	37.32 ± 1.03 ^c	63.54 ± 0.38 ^a	46.89 ± 1.12 ^b	63.99 ± 0.62 ^a
DH	35.03 ± 0.14 ^b	36.93 ± 0.48 ^{ab}	22.08 ± 1.77 ^d	25.66 ± 0.93 ^{cd}	24.48 ± 1.74 ^d	37.28 ± 0.54 ^{ab}	29.51 ± 0.69 ^c	40.67 ± 1.19 ^a
Moisture	13.84 ± 0.36 ^a	12.07 ± 0.23 ^a	9.00 ± 1.03 ^b	7.85 ± 0.55 ^b	8.35 ± 0.81 ^b	7.65 ± 0.30 ^b	8.03 ± 0.54 ^b	7.28 ± 1.06 ^b
Protein	23.16 ± 0.22 ^b	24.31 ± 0.49 ^b	8.51 ± 0.34 ^d	11.03 ± 0.34 ^{cd}	11.82 ± 1.11 ^{cd}	25.37 ± 1.56 ^b	15.44 ± 0.89 ^c	34.51 ± 1.56 ^a
Fat	5.35 ± 0.21 ^a	5.28 ± 0.39 ^a	4.37 ± 0.22 ^b	4.46 ± 0.06 ^b	5.12 ± 0.01 ^{ab}	5.30 ± 0.13 ^a	4.94 ± 0.09 ^{ab}	5.10 ± 0.14 ^{ab}
Ash	3.75 ± 0.33 ^d	4.09 ± 0.17 ^d	5.06 ± 0.09 ^c	5.27 ± 0.06 ^c	4.01 ± 0.01 ^d	4.02 ± 0.01 ^d	6.28 ± 0.06 ^b	7.63 ± 0.19 ^a

treatments had no significant effect ($P > 0.05$) on moisture content. Furthermore, the moisture content decreased compared to that of the raw materials of the Sailfin fish by 59.14%.

All treatments had significantly different ash levels ($P < 0.05$), with values ranging from $3.75 \pm 0.33\%$ to $7.63 \pm 0.19\%$. In addition, there was a significant increase in ash levels with pH treatments of 5 and 9.

Molecular weight

The molecular weight characteristics of FPH from different treatments were visualized using the SDS-PAGE method (Figure 3). Moreover, the 12-hour hydrolysis formed 11-protein bands with molecular weights ranging from 7.23-123.03 kDa, while the 24-hour hydrolysis formed a 13-protein band with a molecular weight range of 6.14-118.17 kDa.

Determining the optimum process

The response surface methodology (RSM) method is a common method for analyzing process optimization. Therefore, to achieve the best characteristics of FPH (in terms of yield, antioxidants, DH, moisture content, ash content, fat content, and protein content), two factors were optimized, namely pH and hydrolysis duration. The white area on the contour plot indicated the optimum condition for (*Pterygoplichthys pardalis*) hydrolysis process (Figure 4). It shows that the optimum pH for hydrolysis ranged from pH of 8.8 to 9 and hydrolysis duration for 22.8 – 24 hours. Therefore, based on our experimental treatment, the best Sailfin catfish FPH processing was at pH 9 for 24-hour hydrolysis. The treatment that still yielded acceptable results based on FPH quality standard is shown from the formation of white areas on the contour plot (Figure 4). The treatment received by the response ranges from a pH of 8.8 to 9 and a hydrolysis duration of 22.8 – 24 hours. It results that the best FPH processing was for a pH 9 and a 24-hour hydrolysis.

Amino acid composition

The amino acid content analysis was carried out only on the FPH produced using the optimal treatments. The amino acids detected in the yielded FPH is shown in Table 3. The result showed that eight essential and seven non-essential amino acids were detected. The amino acids such as lysine, leucine, glutamic acid, aspartic acid, and glycine were dominant in the FPH samples from sailfin catfish.

Figure 3. SDS-PAGE patterns of fish protein hydrolysate from sailfin catfish.

Figure 4. Contour Plot of optimized process for fish protein hydrolysate.

Table 3. Comparison of amino acid composition between hemp seed protein isolate (IFPH), sailfin catfish and Nile tilapia.

		FPH		
Amino acids		Sailfin catfish (<i>Pterygoplichthys pardalis</i>)* (%)	Nile tilapia (<i>Oreochromis niloticus</i>)** (%)	Commercial FPH*** (%)
Essential				
1	L-Isoleucine	5,33	4,32	4,30
2	L-Leucine	9,14	9,23	7,10
3	L-arginine	4,76	10,41	7,10
4	L-Lysine	10,32	-	7,50
5	L-Phenylalanine	4,28	4,37	3,70
6	L-Threonine	5,58	5,26	3,90
7	L-Valin	7,56	4,76	4,90
8	L-Histidine	2,33	2,42	2,10
Total essential		49,30	40,77	40,60
Non-essential				
1	L-Alanine	6,14	7,71	6,50
2	L- Aspartic acid	9,54	11,61	8,80
3	L-Glutamic acid	12,35	21,03	13,50
4	Glycine	9,58	5,34	11,10
5	L-Serine	5,12	4,66	4,90
6	L-Proline	2,84	6,44	5,60
7	L-Tyrosine	5,14	2,47	-
Total non-essential		50,71	59,26	50,40

Source:*This study.

**Foh et al. (2011).

***International Quality Ingredients (2019).

Discussion

The protein and fat values obtained were higher than in a previous study by Munandar and Eurika (2016) which showed that the protein levels and fat content were 19.71% and 1.73%. According to Tunjungsari (2007), the chemical composition of fish meat varies depending on the species, age level, habitat, and feeding locations.

The yield obtained in this study was lower than the hydrolyzed protein yield of salmon waste protein of 65.17%, obtained without added enzymes, for a pH 2.5 and at room temperature, and for a hydrolysis duration of 18 hours (Nurdiani *et al.*, 2015). According to Jamil *et al.* (2016), differences in yields from FPH are due to variations in species, parts of the fish used, types of enzymes used, and the applied hydrolysis conditions.

The antioxidant activity of FPH from sailfin catfish was previously processed without the addition of enzymes, and for pH 7, at a temperature of 55°C, and a hydrolysis duration of six hours (Baehaki *et al.*, 2015). Data on the antioxidant activity of snakehead (*Channa striata*) FPH were significantly higher compared to those of sailfin catfish. The FPH was processed using the addition of protease enzyme at pH 7 for 90 min at 55°C, which gave an antioxidant activity of 20.7% (Baehaki *et al.*, 2020). The antioxidant peptides from fish proteins are considered safe and healthy due to their low molecular weight, easy absorption, low cost, and high activity (Sarmadi and Ismail, 2010).

The degree of hydrolysis measured in this study was lower than that of the yellowfin fish's (*Limanda aspera*) waste protein hydrolysis samples with the addition of mackerel digestive tract enzymes, at pH 10, a temperature of 50°C, and a 3-hour hydrolysis duration, by 67% (Jun *et al.*, 2004); it was also lower than that in catfish (*Pangasius pangasius*) FPH obtained without the addition of enzymes, at pH 7, a 55°C temperature, and a 6-hour hydrolysis, by 63.21% (Baehaki *et al.*, 2015). According to Hasnaliza *et al.* (2010), the increase in DH is due to an increase in dissolved peptides and amino acids in TCA, which was terminated during hydrolysis.

The protein levels obtained were similar to the hydrolysate protein of catfish (*Pangasius pangasius*) without enzymes, at pH 7, 55 °C, and hydrolysis duration of 6 hours, with a value of 20.86% (Baehaki *et al.*, 2015). The protein level in FPH was higher than that in raw material due to the dissolution of proteins during hydrolysis, and the separation of solids and non-protein substances during centrifugation (Chalamaiah *et al.*, 2010). According to Bautista (1999), the hydrolysis duration affects the protein levels of FPH. The protein will increase by approximately 3% when the hydrolysis length is extended from 60 to 120 minutes.

In this study, the fat content produced was lower than the hydrolysate fat content of the salmon waste protein obtained without adding enzymes, at pH 2.5, and a hydrolysis duration of 18 hours, which was 18.90% (Nurdiani *et al.*, 2015; Idowu *et al.*, 2018). The process reduces the moisture of the product. This is due to the use of high-temperature spray drying methods for the processing of FPH, which removes most of the water content. According to Riansyah *et al.* (2013), the ability of the material to release water from its surface is more remarkable with increased drying air temperature used, and a longer drying process to produce a lower moisture content. This shows that the water content of the FPH produced was lower than that of the spray-dried FPH from Nile tilapia and Tambelo, which yielded water contents of $9.06 \pm 0.09\%$ and $10.16 \pm 0.17\%$, respectively (Anwar and Rosmiati, 2013; Annisa *et al.*, 2017). Mixing acidic and alkaline compounds in protein hydrolysate solutions leads to the formation of salt compounds, causing the ash levels to increase in protein hydrolysates (Wijayanti *et al.*, 2015). In addition, the ash content in the hydrolysate was also influenced by the release of minerals during hydrolysis, especially from bones (Ido *et al.*, 2018).

The longer hydrolysis time was more effective in breaking protein bonds into peptides and amino acids with low molecular weight. This hydrolysis process caused structural changes, where proteins slowly degraded into smaller peptide units (Rawdkuen *et al.*, 2018). The low molecular weight of FPH also support its potential for application as a functional food product.

Optimal hydrolysis depends on the reaction conditions, such as the type of endogenous protease. Moreover, the raw material has specific optimum conditions for its endogenous enzymes. For example, the endogenous enzymes of the digestive tract of snapper and mackerel function best at pH 9 and temperatures of 45°C and 55°C, respectively (Singh and Benjakul, 2018). Meanwhile, parrotfish have showed better results when processed at pH 8–9 and after reaction times of 21.5–24 h (Prihanto *et al.*, 2020).

Variations in the composition of the amino acids produced were related to differences in prevailing hydrolysis conditions such as enzyme type, pH, and hydrolysis temperature (Klompong *et al.*, 2009) and the total essential amino acid contents were 49.30%. This result is higher than that of total essential amino acid in Nile tilapia (*Oreochromis niloticus*) and commercial hemp seed protein isolate (HPI), which were previously found to be 40.77% and 40.6%, respectively

(Foh *et al.*, 2011; International Quality Ingredients, 2019). Compared to other amino acids, glutamate showed the highest proportion with 12.35%. This result is in line with the FPH of Nile tilapia, which had the highest glutamic acid content of 21.03% (Foh *et al.*, 2011). According to Chalamaiah *et al.* (2012), most reported FPH to have the highest content of amino acids of the types of aspartic acid and glutamate.

Conclusion

The FPH characteristics of the sailfin catfish (*Pterygoplichthys pardalis*) were affected by two factors, which were pH and hydrolysis duration. Based on the results, the best processing conditions to obtain optimal characteristics for FPH were a yield of 57.39%, antioxidant levels of 63.99%, a DH of 40.67%, a moisture content of 7.28%, ash content of 7.63%, fat content of 5.10%, and protein content of 34.51%. Furthermore, the treatments ranged from a pH of 8.8–9 and a hydrolysis length of 22.8–24 hours, which led to total essential and non-essential amino acid levels of 49.30% and 50.71%, respectively.

Data availability

Underlying data

Figshare: Raw data for Sailfin Catfish (*Pterygoplichthys pardalis*) Fish Protein Hydrolysate.

<https://doi.org/10.6084/m9.figshare.16566360> (Prihanto *et al.*, 2021)

This project contains the following underlying data:

- Proximate of Sailfin Catfish (*Pterygoplichthys pardalis*)
- Yield, antioxidant, and proximate of the Sailfin Catfish (*Pterygoplichthys pardalis*) Fish Protein Hydrolysate
- Amino acid of the best treatment

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

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References

- Annisa S, Darmanto YS, Amalia U: **Influence of differences in fish species on fish protein hydrolysate with the addition of the papain enzyme.** *Indonesian J. Fish. Sci. Techn. (IJFST)*. 2017; **13**(1): 24–30.
[PubMed Abstract](#) [Publisher Full Text](#)
- Anwar LO, Rosmawati: **Hydrolysate characteristics of the hydrolysis protein tambelo (*Baetronophorus* sp.) which is hydrolyzed using the enzyme papain.** *Biogenesis*. 2013; **1**(2): 133–140.
- AOAC: *Official methods of analysis*. Washington DC: Association of Official Analytical Chemists; 2005.
- Baehaki A, Lestari SD, Romadhoni AR: **Hydrolysis of catfish protein uses the enzyme papain and its hydrolysate antioxidant activity.** *JPHPI*. 2015; **18**(3): 230–239.
[PubMed Abstract](#) [Publisher Full Text](#)
- Baehaki A, Widiastuti I, Nainggolan C, *et al.*: **Antioxidant Activities Of Snakehead (*Channa striata*) Fish Skin: Peptides Hydrolysis Using Protease Tp2 Isolate From Swamp Plant Silage.** *Potravinarstvo Slovak. J. Food Sci.* 2020; **14**: 379–384.
- Bautista I: **Recovery of proteins from fish waste products by alkaline extraction.** *Eur. Food Res. Technol.* 1999; **210**: 84–89.
[PubMed Abstract](#) [Publisher Full Text](#)
- Boogers I, Plugge W, Stokkermans YQ, *et al.*: **Ultra-performance liquid chromatographic analysis of amino acids in protein hydrolysates using an automated pre-column derivatisation method.** *J. Chromatogr. A*. 2008; **1189**(1–2): 406–409.
[PubMed Abstract](#) [Publisher Full Text](#)
- Chalamaiah M, Kumar BD, Hemalatha R, *et al.*: **Fish protein hydrolysates: Proximate composition, amino acid composition, antioxidant activities and applications: A review.** *Food Chem.* 2012; **135**: 3020–3038.
[PubMed Abstract](#) [Publisher Full Text](#)
- Chalamaiah M, Rao GN, Rao DG, *et al.*: **Protein hydrolysates from meriga (*Cirrhinus mrigala*) egg and evaluation of their functional properties.** *Food Chem.* 2010; **120**: 652–657.
[PubMed Abstract](#) [Publisher Full Text](#)
- Donkor ON, Stojanovska L, Ginn P, *et al.*: **Germinated grains – Sources of bioactive compounds.** *Food Chem.* 2012; **135**(3): 950–959.
[PubMed Abstract](#) [Publisher Full Text](#)
- Foh MBK, Kamara MT, Amadou I, *et al.*: **Chemical and physicochemical properties of tilapia (*Oreochromis niloticus*) fish protein hydrolysate and concentrate.** *Int. J. Biolog. Chem.* 2011; **5**(1): 21–36.
[PubMed Abstract](#) [Publisher Full Text](#)
- Guo Y, Michael N, Madrigal JF, *et al.*: **Protein hydrolysate from *Pterygoplichthys disjunctivus*, Armoured Catfish, with high antioxidant activity.** *Molecules*. 2019; **24**(8): 1628.
[PubMed Abstract](#) [Publisher Full Text](#) [Free Full Text](#)
- Hadiaty RK: **Diversity and loss of fish species in the Ciliwung river and Cisadane River.** *Biology news*. 2011; **10**(4): 491–504.
- Hasnaliza H, Maskat MY, Wan AWM, *et al.*: **The effect of enzyme concentration, temperature and incubation time on nitrogen content and degree of hydrolysis of protein precipitate from cockle (*Anadara granosa*) meat wash water.** *Int. Food Res. J.* 2010; **17**: 147–152.
- Hoyle NT, Merritt JH: **Quality of fish-protein hydrolysates from herring (*Clupea harengus*).** *J. Food Sci.* 1994; **59**(1): 76–79.
[PubMed Abstract](#) [Publisher Full Text](#)

- Hsu K: **Purification of antioxidative peptides prepared from enzymatic hydrolysates of tuna dark muscle by-product.** *Food Chem.* 2010; **122**: 42–48.
[Publisher Full Text](#)
- Idowu AT, Benjakul S, Sinthusamran S, *et al.*: **Protein hydrolysate from salmon frames: production, characteristics and antioxidative activity.** *J. Food Biochem.* 2018; **43**(2): 1–12.2018.
International Quality Ingredients: Fish Protein Hydrolysate. 2019. Accessed January 24, 2019.
[Reference Source](#)
- Jamil NH, Ruhaya AHN, Sarbon NM: **Optimization of enzymatic hydrolysis condition and functional properties of eel (*Monopterus* sp.) protein using response surface methodology (RSM).** *Int. Food Res. J.* 2016; **23**(1): 1–9.
- Je J, Park P, Kim S: **Antioxidant activity of a peptide isolated from Alaska pollack (*Theragra chalcogramma*) frame protein hydrolysate.** *Food Res. Int.* 2005; **38**(1): 45–50.
[Publisher Full Text](#)
- Jun SY, Park PJ, Jung WK: **Purification and characterization of an antioxidative peptide from enzymatic hydrolysate of yellowfin sole (*Limanda aspera*) frame protein.** *Eur. Food Res. Technol.* 2004; **219**: 20–26.
- Klompong V, Benjakul S, Yachai M, *et al.*: **Amino acid composition and antioxidative peptides from protein hydrolysates of yellow stripe trevally (*Selaroides leptolepis*).** *J. Food Sci.* 2009; **74**(2): C126–C133.
[Publisher Full Text](#)
- Laemmli UK: **Cleavage of structural proteins during assembly of the head of bacteriophage T4.** *Nature.* 1970; **227**(5259): 680–685.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Latifah A: **Antioxidant activity and bioactive components of hydrolyactive protein offal white snapper (*Lates calcalifer*).** Thesis. Bogor: FPIK, IPB; 2013.
- Meldstad F: **Hydrolysis of Marine Cod (*Gadus morhua*) head.** Thesis. Trondheim: Norwegian University of Science and Technology; 2015. NTNU, Faculty of Natural Sciences, Department of Biotechnology.
- Munandar K, Eurika N: **Economic diversity of fish and heavy metal content of Pb and Cd in Sailfin fish in Bedadung Jember River.** *Proc. Bio. Educ. Conf.* 2016; **13**(1): 717–722.
- Nalinanon S, Benjakul S, Kishimura H, *et al.*: **Functionalities and antioxidant properties of protein hydrolysates from the muscle of ornate threadfin bream treated with pepsin from skipjack tuna.** *Food Chem.* 2011; **124**: 1354–1362.
[Publisher Full Text](#)
- Nurdiani R, Dissanayake M, Street WE, *et al.*: **Sustainable use of marine resources – turning waste into food ingredients.** *Int. J. Food Sci. Technol.* 2015; **50**: 2329–2339.
[Publisher Full Text](#)
- Panase P, Uppapong S, Tuncharoen S, *et al.*: **Partial replacement of commercial fish meal with Amazon sailfin catfish *Pterygoplichthys pardalis* meal in diets for juvenile Mekong giant catfish *Pangasianodon gigas*.** *Aquaculture Reports.* 2018; **12**: 25–29.
[Publisher Full Text](#)
- Prihanto AA, Nurdiani R, Bagus AD: **Production and characteristics of fish protein hydrolysate from parrotfish (*Chlorurus sordidus*) head.** *PeerJ.* 2019; **7**: e8297.
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Prihanto AA, Nurdiani R, Sari LW: **Raw Data of Sailfin Catfish (*Pterygoplichthys pardalis*) Fish Protein Hydrolysate.** figshare. Dataset. 2021.
[Publisher Full Text](#)
- Qoyyimah FD, Elfidabari D, Fahmi MR: **Identification of Sailfin fish (*Loricariidae*) based on the character of abdominal patterns in the waters of Ciliwung.** *J. Biol.* 2016; **20**(1): 40–43.
- Rawdkuen S, Rodzi N, Pinijsuwan S: **Characterization of sachai inchi protein hydrolysate produced by crude papain and Calotropis proteases.** 2018; **98**: 18–24.
- Riansyah A, Supriadi A, Nopianti R: **Effect of temperature and drying time differences on the characteristics of siamese salted fish (*Trichogaster pectoralis*) using an oven.** *Fishtech.* 2013; **2**(1): 53–68.
- Sarmadi BH, Ismail A: **Antioxidative peptides from food proteins: A review.** *Peptides.* 2010; **31**(10): 1949–1956.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Singh A, Benjakul S: **Proteolysis and its control using protease inhibitors in fish and fish products.** *Compr Rev Food Sci Food Saf.* 2018; **17**: 496–509.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Susanto DA: **Pleco, exotic ornamental Sailfin.** Jakarta. 2014.
- Swanepoel JC, Goosen NJ: **Evaluation of fish hydrolysate in juvenile African catfish (*Clarias gariepinus*) diets.** *Aquaculture.* 2018; **496**: 262–269.
[Publisher Full Text](#)
- Tunjungsari RM: **Utilization of Sailfin fish (*Hyposarcus pardalis*) in the manufacture of fish chips.** Thesis. Bogor: IPB; 2007.
- Wijayanti I, Romadhon, Rianingsih L: **Effect of the concentration of the enzyme papain on proximal levels and the yield value of protein hydrolysate bandeng fish (*Chanos chanos* Forsk.)**. *PENA akuatika.* 2015; **12**(1): 13–23.

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Nilesh Nirmal

Institute of Nutrition, Mahidol University, Nakhon Pathom, Thailand

Prihanto et al. have studied the production and catherization of sailfin catfish protein hydrolysate. The research topic is important and could influence the nutraceutical market.

However, the authors failed to present well the structure and sound understanding of the outcome. In fact, the whole manuscript need to be re-written with scientific and technical merits and explanations.

Secondly the English language is very poor and lacks consistency. The author can do much better writing and comparing the results. Also the labels of each section need to improve.

The present manuscript lacks thorough discussion and presentation.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Waste utilization, bioactive compounds, bioactivities

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Reviewer Report 08 April 2022

<https://doi.org/10.5256/f1000research.76979.r128074>

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Celia Garcia-Sifuentes

Laboratorio de Bioquímica y Calidad de Productos Pesqueros, Centro de Investigación en Alimentación y Desarrollo A.C. (CIAD), Hermosillo, Mexico

Although the manuscript presents interesting information; there are multiple grammatical and drafting mistakes that make it very hard to understand the context and its relevance. In general, the manuscript lacks a fluent and practical reading and needs to be edited to improve the writing and structure.

The title of the manuscript "Production and characteristics of sailfin catfish (*Pterygoplichthys pardalis*) protein hydrolysate [version 1; peer review: awaiting peer review]" is in my opinion misleading since the small-scale lab methods applied can hardly be called "production", therefore, I suggest improving the manuscript title.

- Describe the significance level and the post-hoc test used for the data analysis
- For the fish hydrolysis process, described if an enzyme was used for the FPH production. The FPH process is not clear. Were autolytic enzymes used?
- Yield calculation is not clear, what does the number of hydrolysates mean?
- Figures and tables seem to be incomplete, example, table 2. Write a footnote, different letters in the same row indicate significant differences. Figure 3, what is A1B1, A2B2, etc.
- Figure 3: The protein/peptides patterns are not clear, maybe because of the separating gel and running conditions of the analysis.
- SDS PAGE Analysis. I suggest including the following information on the method. A) µg of protein loaded per well? B) MW of the standard? C) Software used for the band's analysis?

- Some newer references should be included for the discussion to compare with other authors.

Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Fish by-products

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

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