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The Effect of Boiling Time on Proximate and Sensory Characteristics of Rice Paddy Eel Flour (*Monopterus albus Zuieuw*)

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ABSTRACT

Eel is a fish with high nutritional content that provides significant health benefits. However, its snake-like appearance makes it less popular as a food source. To increase its economic value and utilization, eel can be processed into various products, one of which is a semi-finished product in the form of eel flour. This study aimed to determine the effect of boiling time on the proximate and sensory characteristics of rice field eel flour. A completely randomized design (CRD) was used with four treatments and three replications for proximate analysis (water, ash, protein, fat, and carbohydrates), as well as 20 replications for hedonic quality tests (appearance, aroma, color, and texture). The results showed that the best treatment was obtained at a boiling time of 20 minutes, producing rice field eel flour with a water content of 13.32%, ash content of 5.00%, protein content of 67.44%, fat content of 2.90%, and carbohydrate content of 11.34%. The hedonic quality scores were 6.8 for appearance, 6.5 for color, 6.1 for aroma, and 7.5 for texture.

INTRODUCTION

Eel is a high-protein fish with low fat content. Because of its snake-like appearance, eel is generally less popular among the public. Therefore, it is necessary to process eel into flour (a semi-finished product) that can be further diversified into various products.

Fishmeal is a product derived from fish, either in the form of whole fish or fish processing by-products. The process of producing flour involves removing most of the liquid and some or all of the fat from the fish **(Sihite, 2013)**. Eel flour has been widely used and processed into products such as eel flour–fortified biscuits **(Wulandari *et al*., 2019)** and eel flour substitute biscuits **(Astuti *et al*., 2023)**.

Boiling is one of the methods used in fishmeal processing. In this process, boiling water at around 100°C serves as the heat transfer medium. Boiling can affect both the quality and nutritional content of the resulting product, with the main influencing factor being the duration of heating. For this reason, eel boiling in the production of eel flour was tested at different durations: 0, 5, 10, and 20 minutes, all at 100°C. This was done to examine the effect of boiling time on the proximate characteristics, hedonic quality, and solubility of rice field eel flour. Such research is important for determining how boiling time influences both the proximate composition and sensory attributes of rice field eel flour.

MATERIALS AND METHODS

Tools and materials

The tools used in this study included: grinder, basin, scales, sieve, knife, hot plate, cutting board, beaker glass, dehydrator, porcelain cup, dropper, aluminum cup, measuring cup, desiccator, electric heater, analytical balance, clamp, electric furnace, distillation flask, Soxhlet oven, fat filter paper, condenser, Bunsen burner, fat flask, pipette, Kjeldahl flask, burette, Erlenmeyer flask, boiling stone, volumetric pipette, label paper, test chair, table, plate, pen, and score sheet.

The materials used were: fresh eel, distilled water, mixed catalyst, indicator mixture (methyl red 0.1% and bromcresol green 0.2% in alcohol), solvent (chloroform), H_2SO_4, K_2SO_4, NaOH, $Na_2S_2O_3$ (sodium thiosulfate), HCl, murexide indicator, acetone, plain water, and eel sample.

Research procedure

This research was conducted with modifications to the procedures of **Hikmah *et al*. (2019)** and **Candra *et al*. (2022)**. The stages of making rice field eel flour were as follows:

1. The head and stomach contents were removed (weeding), then the eel was cut and washed with running water until becoming clean.
2. Five hundred grams of eel meat were weighed and boiled at 100°C according to the treatment duration: 0, 5, 10, or 20 minutes.
3. The meat was shredded to separate it from the bones.
4. The meat was dried using a dehydrator at 70°C for 7 hours.
5. The dried eel meat was ground using a grinder and sieved with a mesh size of 60.

Research design

The experimental design used was a completely randomized design (CRD) with four treatments and three replications for proximate and solubility analyses, and 20 replications for the hedonic quality test. The treatments were as follows:

- Treatment O: no boiling

- Treatment A: boiling for 5 minutes
- Treatment B: boiling for 10 minutes
- Treatment C: boiling for 20 minutes

Statistical analysis

Data analysis for yield, solubility, and proximate tests was performed using the analysis of variance (ANOVA) in accordance with the CRD, which consisted of four treatments and three replications. ANOVA was used to determine whether there were significant differences among treatments for the measured parameters. The hedonic quality test was analyzed using the sign test. The formula is:

$$Yij = \mu + \tau i + \varepsilon ij$$

Where:
Yij = observed value for the i-th treatment and j-th replication,
μ = general mean,
τi = effect of the i-th treatment,
εij = experimental error, which is assumed to be normally distributed, independent, and homogeneous with a mean of zero and constant variance.

The sign test is used for the hedonic quality test. **Nasoetion and Barizi (1980)** stated that statistical analysis of hedonic quality test observation data typically uses a sign test with the following formula:

$$x^2 = \frac{[(n1-n2)-1]^2}{n1+n2}$$

Where:
X^2 = Sign test result
n1 = Number of others with a positive sign
n2 = Number of others with a negative sign

RESULTS

This study used rice field eel (*Monopterus albus* Zuieuw) as the main ingredient for making fish meal. The eel used came from Sungai Batang village, Martapura, South Kalimantan Province. Rice field eel meal can be seen in Fig. (1).

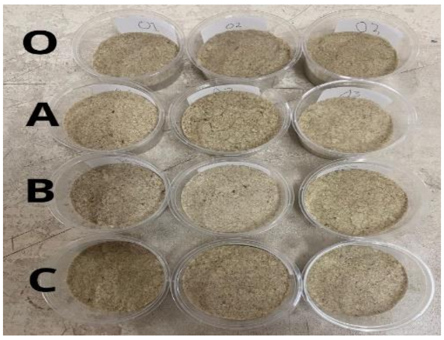

Fig. 1. Rice field eel flour

Description: O) without boiling; A) boiling for 5 minutes; B) boiling for 10 minutes; C) boiling for 20 minutes.

Table 1. Results of calculation of yield and solubility of rice eel flour (*Monopterus albus* Zuieuw)

Solubility	Yield	Treatment
O	7.48±1.02[a]	8.67±2.31[a]
A	9.89±2.13[a]	8.67±0.58[a]
B	9.86±1.16[a]	9.33±2.31[a]
C	9.55±2.37[a]	13.33±4.93[a]

Superscript letter (a) indicates no significant difference ($P<0.05$).

The results of ANOVA calculations of yield and solubility of rice field eel flour with different boiling times show that the calculated F- value is less than the F- table value of 5%, meaning that there is no significant difference between the treatments.

Table 2. Proximate analysis results of rice eel flour (*Monopterus albus* Zuieuw)

Parameter (%)	**Treatments**			
	O	**A**	**B**	**C**
Water content	19.53±0.56[a]	14.81±0.76[b]	13.43±1.36[b]	13.32±0.49[b]
Ash content	4.67±0.24[a]	4.85±0.11[a]	5.12±0.50[a]	5±0.09[a]
Protein content	58.72±1.57[a]	63.30±1.18[b]	66.56±0.48[bc]	67.44±0.54[c]
Fat content	2.06±0.02[a]	2.51±0.30[ab]	2.38±0.17[ab]	2.90±0.36[b]
Carbohydrate content	15.02±1.70[a]	14.53±0.88[a]	1252±1.17[ab]	11.34±1[b]

Different superscript letters (a. b and c) indicate significantly different ($P>0.05$) and very significantly different ($P>0.01$).

Data analysis (Table 2) showed that water content was recorded with high significant differences ($P< 0.01$) between treatments O–A, O–B, and O–C, while no significant differences ($P> 0.05$) were observed between treatments A–B, A–C, and B–C.

Ash content did not differ significantly ($P > 0.05$) among all treatments.

Protein content showed extreme significant differences ($P< 0.01$) between treatments C–O and B–O, and significant differences ($P < 0.05$) between treatments C–A and A–O. No significant differences ($P > 0.05$) were found between treatments C–B and B–A.

On the other hand, fat content did not differ significantly ($P> 0.05$) among most treatments (A–O, B–O, A–B, C–O, C–B, and C–A). However, treatment C–O showed a significant difference ($P< 0.05$).

Eminently, carbohydrate levels showed no significant differences ($P> 0.05$) between treatments O–A, O–B, A–B, and B–C, but were significantly different ($P< 0.05$) between treatments O–C and A–C.

Table 3. Hedonic quality test results

Test parameter	**Average Results of Hedonic Quality Test**			
	O	**A**	**B**	**C**
Appearance	5 ± 1.72^{a}	7.2 ± 1.94^{b}	7.6 ± 0.94^{bc}	6.8 ± 1.82^{c}
Color	4.2 ± 1.51^{a}	6.7 ± 2.27^{b}	7.3 ± 1.17^{b}	6.5 ± 2.04^{b}
Aroma	6.1 ± 3.21^{ab}	6.1 ± 1.37^{a}	5.2 ± 1.28^{b}	6.1 ± 1.77^{ab}
Texture	6.3 ± 2.18^{a}	6.4 ± 1.96^{ab}	7.3 ± 1.87^{ab}	7.5 ± 2.24^{b}

Different superscript letters (a. b and c) indicate significantly different ($P>0.05$) and very significantly different ($P>0.01$).

The hedonic quality test results (Table 3) showed that for appearance, treatments A–O, B–O, and C–O were very significantly different ($P< 0.01$), while treatment C–A was significantly different ($P< 0.05$). While, no significant differences ($P> 0.05$) were found between treatments B–A and C–B.

For color, treatments A–O, B–O, and C–O were very significantly different ($P< 0.01$). Meanwhile, treatments B–A, C–A, and C–B showed no significant differences ($P > 0.05$).

For aroma, treatments A–O, B–O, C–O, and C–B showed no significant differences ($P> 0.05$), while treatment B–A was significantly different ($P< 0.05$).

For texture, treatments A–O, B–O, B–A, C–A, and C–B were not significantly different ($P > 0.05$). However, treatment C–O was significantly different ($P < 0.05$).

DISCUSSION

Rice Yield

The analysis results (Table 1) showed that boiling time did not affect the yield of rice field eel flour. The differences in yield values were likely due to the processing method. During shredding, many fish bones of various sizes were discarded, and during grinding, small fibers did not pass through the sieve, which affected the final yield. According to **Nafidzah *et al*. (2018)**, factors influencing flour yield include the raw materials, particle size, equipment used, and accuracy during processing. This is supported by **Saputra (2023)**, who noted that finer grinding improves sieving efficiency, allowing more flour particles to pass through.

Proximate composition

Water content

The results (Table 2) show that boiling time had a sound significant effect ($P < 0.01$) on the water content of eel flour. The highest water content was in treatment O (without boiling) at 19.53%, while the lowest was in treatment C (20 minutes boiling) at 13.32%. Based on SNI 01-2715-1996, the maximum allowable water content of fishmeal is 12%. Therefore, the eel flour produced in this study did not meet the SNI standard.

Water content is closely related to protein, as water binds to protein via hydrogen bonds. A decrease in water content is usually accompanied by an increase in protein. During boiling, bound water molecules are released from proteins. This finding is consistent with that of **Sipayung *et al*. (2015)**, who stated that cooking decreases the water content of raw materials.

Ash content

The results (Table 2) showed that boiling time had no effect on ash content. The ash content across treatments ranged from 4.67% to 5.12%. According to SNI 01-2715-1996, the maximum ash content in fishmeal is 30%. Thus, all treatments met the SNI standard. Ash content is influenced more by environmental factors than by processing. **Purwaningsih (2011)** reported that habitat and living environment affect mineral intake, which in turn influences ash levels in aquatic organisms.

Protein content

Boiling time had a very significant effect ($P < 0.01$) on protein content (Table 2). The highest protein content was observed in treatment C (20 minutes boiling) at 67.44%, while the lowest was in treatment O (without boiling) at 58.72%.

Protein content increased with longer boiling durations. According to SNI 01-2715-1996, the minimum protein requirement for fishmeal is 45%. Thus, all treatments met the SNI standard. The increase in protein percentage is likely due to the reduction in water content, which concentrated other nutrients. This is in line with **Indiriastuti *et al*. (2012)**, who reported that protein binds water more effectively during processing, thereby reducing water content and increasing protein proportion.

Fat content

The results (Table 2) indicated that boiling time had a significant effect ($P < 0.05$) on fat content. Treatment C (20 minutes) had the highest fat content (2.90%), while treatment O (no boiling) had the lowest (2.06%). According to SNI 01-2715-1996, the maximum fat content for fishmeal is 12%, and all treatments met this standard.

Fat content strongly influences the quality of fishmeal. High fat accelerates rancidity, reducing shelf life **(Wahyu & Assadad, 2016; Orlan *et al*., 2019)**. The boiling process likely increased fat content due to moisture reduction, which allowed fat to be released from the meat tissue.

Carbohydrate content

The results (Table 2) illustrate that boiling time significantly affected carbohydrate content. The highest value was observed in treatment O (no boiling) at 15.02%, while the lowest was in treatment C (20 minutes boiling) at 11.34%.

Carbohydrate levels decreased with longer boiling durations, likely due to cell wall permeability during heating, which allowed starch and carbohydrates to leach out. In contrast, **Yatsin *et al*. (2022)** reported that longer boiling increased carbohydrate values, suggesting differences due to species or processing conditions.

Organoleptic test

Appearance

Based on Table (3), the highest appearance score was in treatment B (10 minutes boiling) at 7.6, while the lowest was in treatment O (no boiling) at 5. According to SNI 01-2346-1991, treatment B is considered acceptable with a bright but slightly unclear appearance, whereas treatment O did not pass the standard due to its dull and unclean appearance. This may be due to carotenoid pigments in fat, which are unstable during boiling and drying at high temperatures, leading to discoloration **(Farida *et al*., 2024)**.

Color

The highest color score was in treatment B (10 minutes) at 7.3, while the lowest was in treatment O (no boiling) at 4.2. Treatment B met the SNI standard with a grayish-white color, while treatment O did not meet the standard due to its brownish-gray color. Similar to appearance, carotenoid pigments in eel fat likely caused these differences **(Farida *et al*., 2023)**.

Aroma

The highest aroma score was found in treatments O, A, and C (6.1), while the lowest was in treatment B (5.2). According to SNI 01-2346-1991, treatments O, A, and C were acceptable, while treatment B was not. Fishmeal typically has a characteristic fishy aroma, attributed to high protein content **(Purnamasari *et al*., 2018)**.

Texture

The highest texture score was in treatment C (20 minutes) at 7.5, while the lowest was in treatment O (no boiling) at 6.3. Treatments B and O met SNI standards with smooth, dry textures and no clumping. Texture is associated with water content—lower water content results in drier flour **(Soeparyo, 2018)**. Less smooth textures are usually caused by clumping due to high water and fat content.

Solubility

The results (Table 1) showed that boiling time did not affect the solubility of rice field eel flour. Lower water content generally increases solubility because the flour disperses more easily **(Tamaya *et al*., 2020)**. According to **Prakusya (2021)**, fat is poorly soluble in water; thus, higher fat content reduces solubility. Protein content also influences solubility, as high-temperature processing causes denaturation and coagulation, reducing solubility. Denatured proteins aggregate, form hydrophobic bonds, and limit dissolution **(Winarno & Sutrisno, 2002)**.

CONCLUSION

The proximate analysis (water, ash, protein, fat, and carbohydrate) showed that different boiling times had a very significant effect on water and protein content, a significant effect on fat and carbohydrate content, and no significant effect on ash content in rice field eel flour. The organoleptic test results indicated that boiling time had a very significant effect on appearance and color but no significant effect on aroma and texture.

The best boiling time for processing rice field eel flour was treatment C (20 minutes), which produced flour with the most favorable proximate composition and sensory characteristics.

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