Substitution of fermented maggot \((\textit{Hermetia illucens})\) flour on commercial feed towards protein retention and energy retention in tambaqui \((\textit{Colossoma macropomum})\) meat

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Abstract. \textit{Colossoma macropomum} is one of the fisheries commodities that has high economic value. It is necessary to use quality feed, such as maggot, to increase its production. Since fish growth is largely influenced by nutrient content in feed and fish energy needs Maggot has high protein content of 40-50% and fat content 29-32%. This study aimed to determine the retention of protein and retention of \textit{Colossomamacropomum}. This study used an experimental method with a Completely Randomized Design consisting five treatments and four replications. The provided treatment was a commercial feed which was replaced by the maggot fermentation with different doses. The treatments used in this study were: treatment P0 (0%), P1 (12%), P2 (14%), P3 (16%) and P4 (18%). Parameters observed in this study were protein retention and energy retention. This research used Variant Of Analysis (ANOVA) for data analysis. The result showed that the substitution of maggot fermentation flour on commercial feed for 30 days of maintenance was significantly different \((p<0.05)\) on protein retention. While the energy retention, result showed no significantly different \((p>0.05)\). The protein retention value of \textit{Colossoma macropomum}'s meat was 7.8568% -10.3620% and the energy retention showed 3.9868% -5.2540%.

1. Introduction
Tambaqui \((\textit{Colossoma macropomum})\) is a fishery commodity that has high economic value. This fish is originally from Brazil and comes to Indonesia as an ornamental fish, then developed into consumption fish \([1]\). Recently, tambaqui is sought after by the public as consumption fish. This fish has been widely cultured in Indonesia because it has several advantages, such as high adaptability, fast growth, and tasty \([2]\). Therefore the tambaqui aquacultured continues to develope.

Feed is one of the important aspects in the continuity of fish farming, including tambaqui fish cultured. Good quality feed can increase production \([3]\). The use of insects as a source of feed protein has been studied by researchers in the world. The superiority of protein derived from insects is more
economical, environmentally friendly and has an important role naturally [4, 5]. Black soldier fly (BSF) is one of the insects that can be developed as feed ingredients. The BSF protein content is quite high (40-50%) with fat content ranging from 29-32% [6].

However, maggot also has a high crude fiber content of 18.82% [7]. High fiber content in feed will accelerate the rate of food travel in the digestive tract so that the chance of the digestive tract in absorbing food substances in the feed decreases [8]. The content of crude fiber in maggot can be reduced through the fermentation process using cellulytic probiotics containing bacteria *Enterobacter* sp, *Bacillus* sp, *Cellulomonas* spp and *Actinomyces* spp [9]. The fermentation process will degrade crude fiber into simpler molecules. Based on the background above, the use of maggot flour as a substitute in commercial feed needs to be examined through the protein and energy retention of tambaqui’s meat. Protein retention is a comparison between the amount of protein stored in the form of tissue in the body of a fish and the amount of protein consumed in feed while energy retention is the amount of feed energy consumed by fish that can be stored in the body [10]. Protein and energy retention used in this study to determine the performance of fermented maggot as Tambaqui’s feed substitution.

2. Materials and methods

2.1. Experimental preparation

The materials used in this study included the seeds of Tambaqui (*Colossoma macropomum*) fish with size of 5-7 cm from the Gunung Sari Ornamental Fish Market. The fish used for the study were 200 individuals (10 fishes for each tank). Maggot (*Hermetia illucens*) used in this study was 14 days old originating from Puspo Agro Sidoarjo. Fermented ingredients consisting of probiotics BioMC4, molasses, and distilled water. BioMC4 Probiotics contain *Enterobacter* sp, *Bacillus* sp, *Cellulomonas* spp and *Actinomyces* spp bacteria.

The maggot flour making process based on previous study and them substituted in commercial feed [12]. The method used in this study was the experimental method using a Completely Randomized Design (CRD) consisting of 5 treatments with each of 4 replications. The used treatments were P1(Commercial Feed 99% + 1% Tapioca Flour); P2 (Commercial Feed 87% + 1% Tapioca Flour + Fermentation of Maggot Flour 12%); P3 (85% Commercial Feed + 1% Tapioca Flour + Fermented Maggot Flour 14%); P4 (Commercial Feed 83% + 1% Tapioca Flour + Fermentation of Maggot Flour 16%) and P5 (Commercial Feed 81% + 1% Tapioca Flour + Fermentation of Maggot Flour 18%). The feed was given to tambaqui fish every for 30 days.

2.2. Proximate analysis and determination of protein-energy retention

After maintained for 30 days, the fish meat was taken and weighed 10 grams for proximate analysis. The proximate analysis and protein-energy retention determination was used the previous method [10].

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\text{Protein Retention} = \frac{(\text{final protein value} - \text{initial protein value}) \times \text{feed protein level} \times 100}{\text{consumed feed (g)}}
\]

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\text{Energy Retention} = \frac{(\text{final energy value} - \text{initial energy value}) \times \text{feed energy level (kcal)}}{\text{consumed feed (g)}} \times 100
\]

3. Results and discussion

The results of protein retention showed in Table 1. Protein retention is a comparison between the amount of protein stored in the form of tissue in the body of a fish and the amount of protein consumed in feed [1]. Based on the results of statistical analysis showed that the substitution of fermented maggot flour in commercial feed showed significantly different results (p <0.05) on protein retention of freshwater Tambaqui fish meat. Based on the Table 1, P0 was not significantly different
with P2. The substitution of 12% fermented maggot flour had the same effect on protein retention with the control. This indicated that the addition of 12% maggot flour substitution could be used in Tambaqui aquaculture to be substituted in commercial feed. This was because maggot had a high protein content (40-50%) [6]. The high protein retention showed a better value because protein in feed with high biological value would spur greater body protein accumulation compared to proteins with low biological value so that there were still remaining proteins stored in the body [11]. Protein had important role in the fish body to arrange or repair damaged body cells, as well as the fish body for daily metabolism [12]. The use of feed with the appropriate protein content and optimum amount affected the formation of new tissue so that the growth rate increased [13, 14].

| Treatment | Protein retention ± SD (%) |
|-----------|----------------------------|
| P0 (0%)   | 10.362ᵇ ± 1.594            |
| P1 (12%)  | 8.980ᵃᵇ ± 1.229            |
| P2 (14%)  | 9.838ᵇ ± 0.606             |
| P3 (16%)  | 9.522ᵇ ± 0.864             |
| P4 (18%)  | 7.856ᵃ ± 0.712             |

Note: Different superscripts in the same column show significant differences (p<0.05).

The results of energy retention showed in Table 2. Based on the results of statistical analysis showed that the substitution of fermented maggot flour in commercial feed showed not significantly different results (p >0.05) on energy retention of freshwater tambaqui fish meat. It meant all the treatment value had same effect. Energy retention was influenced by the nutrient content of the feed (protein, fat and carbohydrate) [15, 16]. As explain before that maggot had high protein content [6]. Not only protein, maggot also had rich fat content ranging from 29-32% [6]. Previous study indicated that the carbohydrate of maggot showed 1.76-1.9% [17]. If the energy content in the feed was high it would produce a huge value of energy retention [18]. It was indicated that feed fish was important to increase the production of aquaculture production [19].

| Treatment | Energy retention ± SD (%) |
|-----------|----------------------------|
| P0 (0%)   | 5.254ᵇ ± 1.205            |
| P1 (12%)  | 4.129ᵃ ± 0.781             |
| P2 (14%)  | 4.633ᵇ ± 0.309             |
| P3 (16%)  | 4.517ᵇ ± 0.516             |
| P4 (18%)  | 3.986ᵃ ± 0.622             |

Note: Different superscripts in the same column show not significant differences (p>0.05).

4. Conclusion
The fermented maggot flour could be substituted on commercial feed to increase protein and energy retention values of Tambaqui fish meat with the best dose of 12%.

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