Spent Mushroom Substrate Based Fish Feed Affects The Growth of Catfish (*Clarias gariepinus*)

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Abstract. A preliminary study was conducted to identify the effect of Spent Mushroom Substrate (SMS), a biomass from mushroom cultivation, towards catfish growth and intake performance when developed into fish feed. The fish experiment on catfish was conducted up to 12 weeks and analyzed on the weight, length size, survival rate and digestibility for the three types of SMS based feed in pellet form and a commercial pellet that applied for ten catfish each. Among the SMS based fish feed, Ganoderma obtained the highest weight of 32.46 g followed by White (30.71 g) and Abalone (17.74 g). For the length size, Ganoderma, White and Abalone SMS based feed had achieved in average 18.05 cm, 17.12 cm and 14.85 cm respectively. Commercial feed still manage to obtain the highest weight and length size as 39.33 g and 20.83 cm respectively. The survival rate was found 30 % higher in SMS based feed compared to commercial feed. The digestibility study of dry matter for Ganoderma, White and Abalone SMS based feed were found 77.34 %, 78.20 %, 77.76 % respectively whereas for commercial pellet was 60.92 % indicates that SMS based feed was consumed and digested better than commercial feed.

1. Introduction

Spent Mushroom Substrate (SMS) is an organic waste produced from mushroom industry. It is referred to the composted material substrates that have been fully utilized after several harvesting cycle of mushroom cultivation which contain high organic matter [1]. In average, 1 kg production of mushroom will generate 5 kg of SMS [2]. Therefore, an efficient practical method is necessary in managing this valuable organic waste so it can be utilized at their optimum and ensured the safe disposal of SMS into environment.

The demand for fresh mushroom for the whole world is projected to grow 15 % a year and consumption per capita in Malaysia is projected to grow from 1.0 kg in 2008 to 2.4 kg in 2020. As a result, the total demand for mushroom is projected to increase from 23,000 tones/year in 2008 to 72,000 tones/year in 2020 [3]. Thus, production of SMS from mushroom industry definitely will multiple 5 times higher in the near future which gives us nearly 360,000 tones of SMS in 2020 ahead. Apparently, the obvious solution is to increase utilization of SMS and one of such is in fish feed production.
A study had reported a significant biochemical compounds were detected from SMS. A crude protein value had increased from the fresh medium that is from 0.54 g to an average value of 15.95 g for black jelly, white oyster, grey oyster and abalone mushroom spent and the highest from ganoderma 36.6 g due to mycelium present in SMS. This result was similar and comparable to the findings by Peredes et al. [4]. The carbohydrate value was at average of 57.49 (g/kg) and 70.27 (g/kg) of lignin for most types of mushroom spent.

Fish depicted the lowest feed conversion ratio (FCR) which is 1.5 to 2.0 and therefore it is more suitable in using relatively low nutritional content ingredients. It has been estimated that cost of feed production constitutes about 74% of total cost for farm-made feeds and 92% for manufactured pellet feeds [5]. There is potential to improve the profit by using farm made feed to a larger extent by incorporating agriculture waste in the formulation [6].

In Malaysia aquaculture industry, freshwater catfish gives the highest production which is 46 523 tonnes [7] which covers 40% of total production. The most important part during formulating fish feeds were the inclusion level of the protein sources. Fish meal and soybean meal are commonly used protein in commercial catfish diet [8]. Effort to replace fish meal such as earthworm meal [9] wheat middlings and Gracilaria arcuata meal [10] had been conducted with positive effects to the catfish growth.

Referring to the potential of SMS, therefore, this research was conducted to evaluate the African Catfish growth and uptake performance upon feeding with SMS based feed from various type of mushrooms and its survival rate compared to commercial pellet.

2. Materials and Methods

2.1 Sample preparation

Four types of SMS from Ganofarm Sdn. Bhd, Tanjung Sepat, Selangor namely White oyster (*Pleuratos ostreatus*), Abalone (*Pleuratos cystidiosus*) and Ganoderma (*Ganoderma lucidium*) together with Fresh medium (FM), Rubber Saw Dust (RSD) were randomly selected in triplicate each. A total of twenty seven bags were used in this study. All samples were dried at 50°C for 24 hours [11]and the were homogenized for 40 s using Waring Lab blender prior sieving at 550µm size and kept in an airtight container for further analysis. Fish meal and soybean waste, commercial fish pellet and tapioca flour were purchased from local market. Calcium biphosphate and vitamin mix are purchased from Merck Company. Biochemical contents of all samples were obtained from previous study by this group [12] and shows in Table 1.

| Stage   | Types of substrate | Cycle of cultivation | Protein Yield (g/kg) | Carbohydrate yield (g/kg) | Fat Lignin yield (g/kg) | Ash (%) |
|---------|--------------------|----------------------|----------------------|---------------------------|-------------------------|---------|
| Initial | Fresh medium (FM)  | -                    | 0.54                 | 81.13                     | 10.08                   | 1.285   |
|         | Rubber Saw Dust (RSD) | -                    | 0.66                 | 81.06                     | 10.16                   | 4.345   |
| Final   | Abalone            | 6 - 7                | 13.9                 | 62.55                     | 23.33                   | 5.542   |

Table 1: Biochemical composition analysis for different types of Spent Mushroom Substrate
2.2 Formulation and preparation of SMS fish feed into pellet form

Formulation of fish feed was calculated based on Pearson Square method ([Hardy, 2000]). The calculation is based on protein and energy requirement from the entire ingredient used. For the protein concern, the ingredient ratio for fish meal and soybean waste was 2:1. Meanwhile, for energy concern, the ratio for SMS (White, Abalone, Ganoderma), tapioca flour and rice bran was 3:2:1. All calculations by part for the mixed ingredient were illustrated in Table 2. The formulation was calculated based on 32% protein level recommended for African catfish [14].

Table 2: Weight calculation for each ingredient for SMS based pellet

| Element          | Ingredient        | Calculation | Exact value | Sum  | Overall weight |
|------------------|-------------------|-------------|-------------|------|----------------|
| Protein          | Fish meal         | 2/3 (18.19) | 12.12       | 18.19| 111.19         |
|                  | Soybean waste     | 1/3 (18.19) | 6.062       |      |                |
| Energy           | SMS               | 3/6 (93.00) | 46.50       | 93.00|                |
|                  | Tapioca flour     | 2/6 (93.00) | 31.00       |      |                |
|                  | Rice bran         | 1/6 (93.00) | 15.50       |      |                |
| Others           | Vitamin mix       | 2/100 (111.19) | 2.22 | -  | - |
|                  | Calcium bishydrogen | 1/100 (111.19) | 1.11 |      |                |

All ingredients were mixed, pelletized and the final product was steamed at 80°C for 40 minutes [15].

2.3 Growth performance of fish experiment

The feeding pellet for this experiment involved three types of SMS based fish feed namely White, Ganoderma, Abalone and compared to the commercial pellet. Each pellet type was prepared with triplicate container of ten African catfishes in each container. All containers were supported with 0.5 v of aeration air by pressure pump. The optimum temperature was set between 28°C to 30°C and pH between 6.5 to 8.0.

Fish weight: Fishes were caught using fishing net and weighted using analytical balance (Sartorius, TE 2101) and an average value was recorded.

Fish length: Fishes were caught using fishing net and transferred into empty tray. Fish was measured from head to tail using ruler and released back into the tank. The size was determined from week 0 till week 12 and an average value was recorded.

Survival rate: Survived fishes were counted a every week in every tank from week 0 till week 12 and the data was calculated into percentage as follows in Equation 1:

Survival rate % = \( \frac{\text{Number of Catfish left}}{\text{Total catfish}} \times 100\% \)  \( (1) \)

Water pH: The pH of water in a container was measured by pH meter for each type of pellet.

Digestibility test: A digestibility test was conducted on feces of the fish from different pellet type and a commercial pellet. The sample of feces was then analysed for crude protein, total fat, gross energy and
dry matter content. Digestible protein was analysed following the Lowry method [16] and fat analysis using Soxtec method [17]. Dry matter was analysed by standard AOAC (1995) procedures using oven drying at 105°C for 16 hrs. The gross energy analysis, bomb calorimeter (IKA, Japan) was used according to supplier standard procedure.

3. Results and Discussion

Weight increment of Catfish rearing is exhibited by a linear graph in Figure 1. The correlation coefficient obtained shows values above 0.90 means a good response of weight towards types of fed pellet. Meaning that the studied fish feed from SMS based had contributed to the growth of Catfish at different rate. The highest contribution was from Ganoderma as it contains highest amount of protein and carbohydrate, the elements important for the growth of fish. After week 12, there is potential for the fish to gain more weight, however, prolong the rearing duration may increase cost in this process.

![Figure 1. Weight increment of Catfish fed by different types of fish feed](image)

The increment of length for fish fed with various SMS fish feed types is obviously seen from the graph. Gano based fish feed obtained the highest length size (18.05 cm) followed by White (17.12 cm) and Abalone (14.85 cm). The relation between the types of fish feed and size increment was highly correlated as $R^2$ are more than 0.96 indicating that the SMS based feed did contribute to the length of the fish.

For the whole fish experiment throughout the 12 weeks, the survival rate percentage for produced pellets such as Ganoderma SMS pellet, White SMS pellet and Abalone SMS pellet was 76.7% compared to commercial pellet 46.7%.
The survival rate for fish fed with SMS based fish feed is far higher than the commercial fish feed. The value achieved was 76.7% compared to 46.7%.

**Figure 2.** Size increment of Catfish fed by different types of fish feed

The survival rate for fish fed with SMS based fish feed is far higher than the commercial fish feed. The value achieved was 76.7% compared to 46.7%.

**Figure 3.** Number of Catfish survives that fed by different types of pellets.
Result in Figure 4 had shown there were reducing amount of protein percentage for each types of pellets such as Ganoderma SMS pellet reduced from 26.55% to 18.05%, White SMS pellet 26.53% to 17.51%, Abalone SMS pellet 25.07% to 16.04% and commercial pellet 29.1% to 20.37%. Thus, the reduction of protein percentage in African Catfish feces that fed with Ganoderma SMS pellet was 68 %, whereas White SMS pellet, Abalone SMS pellet and commercial pellet were 66 %, 64 % and 70 % respectively.

![Figure 4](image-url)

**Figure 4.** Percentage of protein between different types of pellet and Catfish feces

This result was compared with the amount of total fat percentage in pellet to account the total fat digested by the Catfish. Result had showed that there were reducing amount of total fat percentage for each type of pellets such as Ganoderma SMS pellet reduced from 3.56 % to 0.95%, White SMS pellet 3.38 % to 1.03 %, Abalone SMS pellet 3.12 % to 0.96 % and commercial pellet 4.21 % to 1.05 %. Thus, the reduction of total fat percentage in African Catfish feces that fed with Ganoderma SMS pellet was 73 %, whereas White SMS pellet, Abalone SMS pellet and commercial pellet were 70 %, 69 % and 75 % respectively.
Digestibility in form of dry matter of feces of African catfish fed with different types of pellet from SMS were analyzed and recorded in Figure 6. From the data, the digestibility of dry matter for produced pellet for Ganoderma SMS pellet, White SMS pellet and Abalone pellet were found 77.34 %, 78.20 %, 77.76 % respectively whereas for commercial pellet was 60.92%. Results show that ability of digest for protein, fat and dry matter were higher and better for fish fed with SMS based feed or pellet compared to commercial pellet. This situation can be explained as SMS contents were plant based and had went through composting process by the mushroom that make it easier to be utilized by the fish [18].
Figure 6. Percentage of digestible dry matter (%) in feces of African catfish according to different types of pellet given

4. Conclusion
As a conclusion, fish feed formulated from SMS based fish feed or pellets had supported the growth of catfish up to 12 weeks and almost comparable to commercial fish pellet. In fact, the survival rate and digesting ability of fish fed with SMS based feed was better than commercial feed. Therefore, this research could present the SMS as the potential sources to be incorporated in fish feed.

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