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Research Article
Utilization of Fish Waste as Fish Feed Material as an Alternative Effort to Reduce and Use Waste

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Abstract

Background and Objective: Waste of fish catching and waste of fish fillet processing will cause environmental pollution, but these materials can still be used as raw material for fish feed. The objective of this research was to change fish wastes to be made as fish powder as raw material of fish feed. **Materials and Methods:** This research employed a completely randomized design with three treatments; Treatment A is artificial feed that uses raw material from trash fish, Treatment B is artificial feed that uses raw material from fish fillet waste and as control is factory-made feed. The silver pompano fish stocking was done with stocking density of 20 fishes m^{-3}. The fishes were cultured for 60 days and they were adapted with formulated feed during 7 days before testing. **Results:** Fish powder material in Treatment A coming from trash fish waste had good enough protein content by 43.84%, while fish powder material in Treatment B coming from fish fillet waste had lower protein content by 36.3%. The results showed that the control produced better growth activity indicators compared to Treatment A and B. The results of economic analysis showed that Treatment A and B were cheaper to produce compared to control. **Conclusion:** Fisheries waste both fish catch and fish fillet waste can be used as raw material for making silver pompano fish feed. Utilization of the two wastes has two functions namely saving on aquaculture costs and reducing fisheries waste.

Key words: Fish waste, pollution, raw material, pompano, aquaculture, waste reduction

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The fishing business is growing rapidly and developing and utilizing advanced technology used by fisheries such as in the process of fishing and processing it into products that can meet food needs and other useful products[1]. Fishery product processing activities have a positive impact on the fishermen's economy and provide an increase in the value of the capture fisheries industry sector[2]. The fishery industry does not only produce useful food products but it can be one of state income sources. However, it can also produce various waste in forms of solid, liquid and gas waste[3].

The most of fish catching industry and fish processing industry is not yet able to implement a good environment management principle[4]. In residual waste of fisheries production, there are still many nutrients that are useful and can be used[5]. Waste production from fishing is used by fishermen to produce fish meal even though the protein content is low and is used as raw material for freshwater fish feed[6]. The waste in fish catching and fish fillet processing of most fishermen do not yet utilize as the side product of fish catching business. The waste coming from fish catching product and fillet fish processing still can be used as fish culture feeding material as powder fish product. This effort can also reduce the need for fish powder import[7].

There are much useful and usable nutrition contained in the waste of fishery production[5]. Waste production from fishing is used by fishermen to produce fish meal even though the protein content is low and is used as raw material for freshwater fish feed[6]. The use of artificial feed in silver pompano fish cultivation has been done to replace trash feed that availability in nature has begun to decrease and compete with consumption for humans[8].

Silver pompano fish can be found mostly in Indian Ocean, African, Malaysian and Japan Ocean. This fish live and swim in groups both at sea surface and at the bottom of the sea[7]. The shape of this silver pompano fish seems oval from aside with ratio of 2:1 between length and height. It has small head with mouth located at the end and upper tip of its head with small eyes formed in circle like ring and it has sharp teeth[9].

Fishing business often produces waste, especially fish that are not consumed by humans as well as waste resulting from fillet activities, for fish meat. Opportunities for waste products from fisheries can be made of good quality fish powder as raw material for making artificial feed for marine fish culture especially silver pompano fish.

The purpose of this study was to determine the benefits of fish catch waste and fish fillet processing waste to make fish powder which will be used as an ingredient in fish feed formulations. This is an effort to save the production cost of silver pompano cultivation so as to increase the income of silver pompano cultivators and reduce fish waste.

MATERIALS AND METHODS

This research was conducted in Lampung Marine Culture Development Center, Lampung, Indonesia located in Hanura village of Teluk Pandan sub-district, Pesawaran district, Indonesia. Research conducted from March-June, 2019. The artificial fish feeding formulation making was made in feed factory of Lampung Marine Culture Development Center in Lampung. Fishery waste material was taken from Lempasing fish auction in Bandar Lampung. Waste types were fixed fish processing waste and waste from trash fish. The silver pompano culturing was done in floating net fish cage in Teluk Hurun of Teluk Pandang sub-district, Pesawaran district. The equipment included powdering machine, big scale, digital scale, oven machine, feed molding machine, siever, shovel, floating net fish cage, 18 of fish net with dimension of $1 \times 1 \times 1.5$ m^3, feed container, scoop and proximate analysis device. Materials to use were waste from fish catching (mixed trash fish) and waste from fish processing (side product of trash fish fillet), sample fishes (silver pompano fish) with size between 100-200 g each, commercial artificial fish feed, multivitamin, bonding material, fresh water to soak fish and drugs.

This research employed a completely randomized design with three treatments, Treatment A used artificial feed coming from fishery waste from mixed trash fish, Treatment B used artificial feed coming from waste from side product of fish fillet processing and control by using commercial fish feed to feed silver pompano fishes. All treatments were replicated 6 times.

The silver pompano fish stocking was done with stocking density of 20 fishes/m^3. Fish feeding was done by using pellet with 37% protein content and accompanied with additional supplement. The fishes were cultured for 60 days and they were adapted with formulated feed during 7 days before testing.

Parameters to observe

Absolute weight: It states the fish weight during culturing time with the following formulation[10]:

$$W = Wt\text{-}Wo$$

Where:
W = Absolute biomass growth (g)
Wt = Average fish weight at day-t (g)
Wo = Average fish weight at day-0 (g)

Daily Growth Rate (DGR): Daily weight increase in percentage is formulated as follows[10]:

$$DGR\,(\%) = \frac{LnWt - LnWo}{t} \times 100$$

Where:
DGR = Daily growth rate (%/day)
Wt = Average individual weight at the end of culturing (g)
Wo = Average individual weight at the initial of culturing (g)
t = Culturing time (days)

Survival Rate (SR): Numbers of living fishes until the end of culturing that is expressed in percentage (%) by using the following formula[11]:

$$SR\,(\%) = \frac{\text{Initial numbers of fishes} - \text{number of death fishes}}{\text{Initial numbers of fishes}} \times 100$$

Food Conversion Ratio (FCR): The ratio between amount of feed to consume and biomass weight. The FCR is calculated with the following formula[11]:

$$FCR\,(\%) = \frac{P}{(Bt + Bd) - Bo}$$

Where:
FCR = Food conversion ratio
B_t = Fish biomass at the end of culturing (g)
B_o = Fish biomass at the initial of culturing (g)
B_d = Death fish biomass during culturing (g)
P = Amount of feed consumed during culturing (g)

Protein retention: Protein retention is amount of protein from the given feed that has been converted into protein contained in the fish body. The following formula is used to estimate Protein Retention (PR)[11]:

$$PR\,(\%) \frac{(F - 1)}{P} \times 100$$

Where:
PR = Protein retention
F = Protein content in fish body at the end of culturing (g)
I = Protein content in fish body at the initial of culturing (g)
P = Protein amount consumed by the fish (g)

Sampling of fish body weight and length measurement was conducted each 10 days. Feeding was done twice a day at 08:00 am and 14:00 pm with ad satiation method. Water quality measurement included temperature, Dissolved Oxygen (DO), acidity level (pH) and ammonia conducted at every 14th day.

Statistical analysis: Obtained data were analyzed with Analysis of Variance (ANOVA) at trust level 95% by using SPSS 16 software. When analysis of variance result showed significant difference ($p<0.05$), then analysis was continued by using Tukey test.

Economy analysis: One of success benchmark of marine fish culturing is by estimating its production cost. Some parameters were used to assess culturing business aspects including: price of fish feed, feed consumption amount, production cost for fish culturing and production efficiency level[12].

RESULTS AND DISCUSSION

The main raw material for making silver pompano fish feed is fish meal, which is derived from the by-products of fishing and fish fillet processing waste (Fig. 1), Meat Bone Meal (MBM) flour, Poultry Meat Meal (PMM) flour, Soybean Meal (SBM) flour, Corn Gluten Meal (CGM) flour, tapioca flour, flour, wheat meal flour (pollard), fish oil, vitamins and minerals. Before being used in fish feed formulations, the raw material for fish feed used was proximate analysis and amino acid analysis. The proximate analysis result is presented in Table 1 and the amino acid analysis result is presented in Table 2.

Based on the nutritional content of raw materials for making fish feed as presented in Table 2, while the self-made feed formula is made as Treatment A and B and as a control is factory-made feed as presented in Table 3. Based on the artificial feed formula is made artificial feed and proximate analysis results of the three types of artificial feed are presented in Table 4.

The results of the growth performance indicators of silver pompano fish cultivated for 60 days and the growth rate of silver pompano with different types of feed treatment presented in Table 5. During cultivation, silver pompano fish are given homemade food as Treatment A and B and factory-made feed as control.

Table 1: Proximate analysis of raw material

Raw material	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	EMWN (%)
Fish meal A	43.84	6.02	41.84	0.41	00.16
Fish meal B	36.30	4.83	45.38	0.28	06.80
SBM flour	46.00	1.03	06.51	3.19	30.07
PMM flour	58.26	7.87	13.04	0.46	11.35
CGM flour	60.00	0.25	01.92	0.89	36.94
MBM flour	55.00	7.99	20.82	3.56	12.63
Wheat flour	11.30	1.70	11.01	0.81	63.59
Pollard flour	18.23	3.53	03.58	6.48	56.45
Tapioca flour	01.67	0.20	00.01	1.01	83.11

SBM: Soybean meal, PMM: Poultry meat meal, CGM: Corn gluten meal, MBM: Meat bone meal, Pollard: Wheat meal flour, EMWN: Extract material without nitrogen

Fig. 1(a-b): Raw materials for fish feed, (a) Fish waste captured by fishermen (trash fish), (b) Waste from making fillet fish

The results of an economic analysis which include: Estimated feed costs, production costs and the conversion ratio of silver pompano fish feed for 60 days of cultivation can be seen in Table 6.

Treatment A based on economic analysis showed that production costs are cheaper than control and Treatment B.

Table 2: Amino acid analysis result of fish powder raw material

Parameters	Fish powder A (mg kg^{-1})	Fish powder B (mg kg^{-1})
L-Methionine	7,267.41	4,374.16
L-Sistin	573.68	365.87
L-Histidine	4,720.79	3,354.46
L-Threonine	12,337.92	8,020.98
L-Proline	16,996.03	9,403.00
L-Tyrosine	7,382.29	4,279.65
L-Leucine	14,591.05	11,813.34
L-Asam Aspartat	19,204.42	18,402.16
L-Lysine	11,225.06	11,815.91
Glycine	33,792.81	16,502.92
L-Arginine	19,339.66	9,064.98
L-Alanine	15,536.58	9,904.02
L-Valine	11,598.23	8,663.06
L-Isoleucine	9,162.20	7,100.55
L-Fenilalanin	12,003.84	6,279.55
L-Asam glutamat	30,854.34	24,255.44
L-Serine	11,986.49	7,970.11
L-Triptofan	1,564.34	1,650.24

Based on the Table 1 and 2, fish powder material in treatment A coming from trash fish waste still had good enough protein content by 43.84%, while fish powder material in Treatment B coming from fillet waste had lower protein content by 36.3%. So, both these waste can be used as raw material for feed fish, especially for silver pompano culturing.

This finding proves that fish feed in treatment A can be used as an alternative for silver pompano culturing because of its lower production cost compared to control fish feed (commercial feed). Using trash fish waste for fish meal in fish feed ingredients formulated for silver pompano fish farming will be more beneficial, because in addition to reducing fisheries waste it also saves the cost of aquaculture.

Adewale *et al.*[13] reported that the use of smoked fish waste as replacement for fish powder for catfish feed obtained a more efficient result. In addition, the composition amount of required feed nutrition would depend on some factors including the required fish nutrition and its cost. Used flour from Bambara nut waste in Nigeria to replace fish powder for fish feed has been done[14]. The result was that

Table 3: Result of proximate analysis of artificial feed formulation

	Material (%)		Protein (%)		Fat (%)		Ash (%)		Fiber (%)		EMWN (%)	
	A	B	A	B	A	B	A	B	A	B	A	B
Fish meal A	35.00	45.00	15.34	16.34	2.11	2.17	14.6	20.4	0.14	0.13	0.06	3.06
SBM flour	10.00	10.00	4.60	4.60	0.10	0.10	0.65	0.65	0.32	0.32	3.07	3.07
PMM flour	10.00	10.00	5.83	5.83	0.79	0.79	1.34	1.34	0.05	0.05	1.14	1.14
CGM flour	8.00	8.00	4.80	4.80	0.02	0.02	0.15	0.15	0.07	0.07	2.96	2.96
MBM flour	10.00	10.00	5.50	5.50	0.80	0.80	2.08	2.08	0.36	0.36	1.26	1.26
Wheat flour	12.00	2.00	1.36	0.23	0.20	0.03	1.33	0.22	0.10	0.02	7.63	1.27
Pollard flour	2.00	2.00	0.36	0.36	0.07	0.07	0.07	0.07	0.13	0.13	1.13	1.13
Tapioca flour	3.50	3.50	0.06	0.06	0.01	0.01	0.00	0.00	0.04	0.04	2.91	2.91
Fish oil	8.00	8.00			8.00	8.00						
Vitamin C	0.05	0.05										
Vitamin premix	0.5	0.5										
Taurine	0.1	0.1										
Methionine	0.25	0.25										
Mineral mix	0.3	0.3										
Lysine	0.3	0.3										
	100.0	100.0	37.85	37.71	12.1	11.9	20.3	24.9	1.20	1.10	20.2	16.8

SBM: Soybean meal, PMM: Poultry meat meal, CGM: Corn gluten meal, MBM: Meat bone meal, Pollard: Wheat meal flour, EMWN: Extract meal without nitrogen

Table 4: Result of proximate analysis of artificial feed

Proximate analysis (%)	Control	Feed A	Feed B
Protein	38.88	38.95	38.69
Fat	12.61	6.14	13.46
Water content	5.17	5.18	0.92
Ash	10.62	23.34	27.48
Fiber	0.39	1.13	1.77
EMWN	32.34	25.26	17.38

EMWN: Extract meal without nitrogen

the Bambara nut flour replaced almost 59% of the fish powder portion. Substitute the portion of soybean powder with 10% of cattle feed powder[15]. Looking for sources of protein, both vegetable and animal sources which are cheaper and more environmentally friendly are needed in aquaculture. Phytoplankton especially *Nannocloropsis* sp. isolated from Lampung Mangrove Center as a source of natural food is needed in cultivation, because the nutritional value is very high[16].

Based on Table 3 and 4 showed the protein in the treatment of fish feed A and Treatment B is almost the same as the protein content of the fish feed factory production (control) or in accordance with the standard of fish feed[17]. Feed is one of very influential factors in culturing business. Protein contained in the feed must be in accordance with the fish need to grow[18]. Growth is size increase in length, weight, volume and numbers of body cells over time. Factors influencing fish growth include genetics, sex, age, disease, parasite, food and water temperature[19]. Protein need varies according to fish species and the use of protein in fish feed for growth is influenced by fish size, protein quality, feed energy content, nutrition content balance and feed giving level. Feed protein content is very determinant to feed price, because most feed component is protein[20].

Based on Table 5, it is known that the control showed better growth preformance indicators ($p<0.05$) compared to Treatment A and B. Unless the feed conversion showed that the control was not significantly different ($p = 0.527$) from Treatment A but it was significantly different ($p = 0.01$) from Treatment B. Treatment A and B were significant differences ($p = 0.05$). Table 5 shows that the best growth rate is control when compared to the growth rate of Treatment A and B.

The percentage of live survival of test fish for 60 days of culture was 100% for all treatments as shown in Table 5. This indicates that the feed given to the fish has fairly fulfilled the fish main need, even provided good growth[17]. Feed cost is an important component in marine fish production activities. A proper cost estimation is very important to maximize profit[13]. In this research, feed price/kg for each treatment is Rp. 15,000 for control feed, Rp. 10,130 for Treatment A and Rp. 9,426 for Treatment B. Thus economically it shows that B feed is cheaper than the other two types of feed, but instead the highest FCR value of Treatment B compared to control and Treatment A (Table 6).

High-quality feed is often associated with high costs. This can be seen in Table 6 where in proportion to the results obtained, control feed has the lowest FCR score but shows the highest production cost/kg of fish of Rp. 36,900. The best and more efficient results are obtained by Treatment A with a production cost of Rp. 26,338 fish/kg then proceed with Treatment B with a production cost of Rp. 28,089 fish/kg and this shows they are still more efficient compared to control feed. According to Adewale *et al.*[13], high feed efficiency indicates that only a small amount of protein needs to be degraded to meet energy needs and the rest will be consumed for growth. The use of fisheries waste for the

Table 5: Results of indicator of growth performance

	Treatments		
Parameters	Control	A	B
Initial weight average (g/fish)	106.39±0.59	106.560±0.25	107.61±1.84
Final weight average (g/fish)	212.25±2.05	198.580±2.79	188.83±0.38
Initial length average (cm)	018.63±0.39	18.480±0.36	18.36±0.29
Final length average (cm)	020.81±1.00	20.630±0.16	20.44±0.01
Fed consumption amount (g/day/fish)	004.33±0.14	4.000±0.18	4.03±0.05
Survival (%)	100.00±0.00	100.000±0.00	100.00±0.00
Daily growth rate	001.16±0.03	1.040±0.02	0.94±0.03
FCR	002.46±0.10	2.60±0.05	2.98±0.05
Protein retention	021.85±1.76	20.560±2.27	17.54±1.71

Data are represented as Mean±Standard error, means with the different letter within the same raw are significantly different ($p<0.05$), FCR: Feed conversion ratio

Table 6: Feed cost estimation result in Indonesian Rupiah

Parameters	Control	A	B
Feed price	15,000	10,130	9,426
FCR	2.46	2.6	2.98
Production cost/kg of fish	36,900	26,338	28,089

FCR: Feed conversion ratio

manufacture of fish powder as a substitute for factory-made fish meal, which is used as material for making homemade feed formulations. It will be double beneficial because it can reduce fishery waste and reduce the cost of fish farming.

CONCLUSION

The higher feed protein content will increase growth performance indicators, but will directly correlate with price increases. Utilization of both fisheries waste in addition to reducing waste can also reduce the cost of cultivation of silver pompano.

SIGNIFICANCE STATEMENT

The results of the research prove that Treatment A (waste from catching fish or trash fish) and Treatment B (fillet processing waste) can be used as an alternative feed raw material for cultivation of silver pompano with consideration of lower production costs compared to control feed (commercial feed). The use of trash fish waste and fish fillet processing waste for fish meal as an ingredient for making homemade feed formulations for silver pompano cultivation will be double beneficial because it can reduce fishery waste and reduce the cost of silver pompano fish farming. This study will help researchers to uncover critical areas of fisheries waste exploration as a source of protein for fish feed raw materials that many researchers cannot explore.

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