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Growth performance of brackish water enhanced selected tilapia (BEST) fed with different formulated diet

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Abstract

A 9-week growth trial was conducted to determine the effects of four pelleted diets on the growth performance of Brackish water Enhanced Selected Tilapia (BEST), investigate the proximate analysis of the formulated diets and determine the cost and return. The tested diets were commercial feed, (Diet 1) 75% *Tricanthera gigantea* + 25% Flying fish entrails, (Diet 2) 50% *T. gigantea* + 50% Flying fish entrails, and (Diet 3) 25% *T. gigantea* + 75% Flying fish entrails (FF). The results revealed that 50% *T. gigantea* + 50% Flying fish entrails obtained the highest final weight and gain weight of 64.4 g and 61.4 g, respectively. For the feed conversion ratio, there were no significant differences between the control diet (commercial) and the others (Diets 1, 2, and 3). In terms of length increment, the control diet and Diet 2 had no significant differences ($P<0.05$). The proximate composition of the feeds, such as moisture, crude protein, crude fat, ash, crude fiber, carbohydrates, and gross energy (GE), of the finished feeds was analyzed. Diet 2 was the best feed; animals increased significantly in weight. Based on the return-on-investment (ROI), 50% *T. gigantea* + 50% FF is the most profitable, even better than the commercial feed. Diet 2 obtained 45.98%, which means for every peso investment, there is a corresponding 45.98 centavos. The use of locally available feedstuffs will not only be beneficial to achieve better growth performance of BEST but can also be translated to sizable savings for local fish farmers.

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Introduction

Flying fish are caught throughout the year using surface gill nets as in Brgy. Tatay in Guiuan, Oras, and Binogawan in San Policarpo, Eastern Samar. It was observed that peak months occurred in the months of March to September. Flying fish (Exocoetidae) shared an estimated 75-80% of the total harvest and ranked as the second most dominant species.

Due to the abundance of the species, hundreds of households in the abovementioned coastal barangay depend on the flyingfish fishing industry as one of their main sources of livelihood. Aside from being sold fresh, local skills in fish processing and unique technology on marinating flying fish were also practices by residents and turned out the most potential business in the barangay. Dried fish and "lamayo" (Waray), processing of adult flying fish, involves removal of entrails, roe, and fins, which are discarded as waste. The majority of fish waste is disposed of in the ocean. Significant waste (20-30%) is generated from the fish "lamayo", and this byproduct can be utilized as fishmeal.

Tricanthera gigantea has crude protein content from 15 to 22% in the leaves. The use of fresh leaves of *gigantea* as a supplement to traditional diets for lactating and growing fattening swines or as a replacement for fish meal or soya bean meal for fattening ducks resulted in substantial savings in feed cost with no loss in performance (Nguyen *et al*., 1999).

Combination of using these locally available feedstuffs (flying fish entrails and *T. gigantea*) will help in the formulation of cheap fish diets that will be available in the coastal community, and these will also alleviate the scarcity of edible fish (suitable for human consumption) from being converted into fish meal. These measures will also minimize the water pollution caused by dumping of fish entrails in the coastal area in some municipalities of Eastern Samar.

According to AMEC (2003), these wastes can be used to produce fish protein concentrate, fish oils, and enzymes (such as pepsin and chymotrypsin) as well as fish meal (Murray *et al.*, 2001).

Tilapia has high palatability and nutrient content (Ansah *et al.*, 2014). The average yearly consumption of Filipinos is 4.6 kg per person, yet the production of this commodity has declined 35 percent in recent years due to several factors (FAO-UN, 2017). Hence, there is a considerable threat not only to the livelihoods of farmers and fishermen but also to the country's food security.

The production of tilapia has contributed greatly to world aquaculture. At present, several tilapia strains have been developed for brackish water aquaculture. Brackish water Enhanced Selected Tilapia (BEST) was developed by the Bureau of Fisheries and Aquatic Resources with the aim of promoting brackish water culture of this commodity to further improve tilapia production in the Philippines (Labastida *et al*., 2015).

Preparing quality diets is a complex process that involves several important factors. These factors include the availability of feeds, ease of procurement, high feed production cost, and nutrient composition. Careful attention must be accorded to the nutritional content of animal diets. In aquaculture feed formulation, protein is the main but expensive ingredient, and its quality and quantity play vital roles in promoting fish growth. Feed constitutes approximately 60% of the total operating cost in aquaculture; therefore, the remarkable growth of aquaculture will be greatly benefited by the development of cheaper aqua feed.

The feed formulator's efforts to prepare the feed at lower cost will directly affect the economy of fish farmers (Daniel, 2018). Until recently, fish feeds were prepared with fishmeal as an important protein ingredient; it is agreed that the fish meal requirement for omnivores is approximately 30 to 40% and for carnivores, more than 40%. However, fish meal inclusion levels for both omnivorous and carnivorous fishes have been decreasing significantly at present (Hardy, 2010). Supply becoming significantly low together with the huge demand and higher prices in the world market (Edwards *et al.*, 2004; De Silva and Hasan, 2007).

Fishmeal as a protein source for fish feeds is unsustainable both environmentally and financially (Subasinghe and Philips, 2007; Tacon and Nates, 2007). The major challenge is in availability, quantity, and cost (Krishnankutty, 2005; Yigit *et al.*, 2006; Goda *et al.*, 2007; and Tabinda and Butt, 2012).

As an alternative to fishmeal, many authors have recommended plant-based protein ingredients specifically due to their cost, as they seem cheaper than fishmeal. The results from the previous works of several authors showed no difference in overall performance while being fed alternative protein sources, which inspired many studies to address the partial replacement of fishmeal by utilizing fish entrails and plant-based protein sources. Hence, in this study, an investigation on the utilization of different combinations of plant protein and flying fish entrails was performed to formulate a nutritious feed that is inexpensive without sacrificing the health and growth of the animals. The study utilized an indigenous feedstuff such as fish byproduct (entrails) to minimize the water pollution caused by dumping of fish entrails in the coastal area in some municipalities of Eastern Samar.

Materials and methods

Experimental Design and Diets

In this trial, four experimental diets were tested (commercial feed and three formulated diets). Diets were prepared at the Eastern Samar State University (ESSU) Food Laboratory. The diets had varied proportions of two different protein sources (flying fish entrails and *Trichantera* leaves). Diets contained different percentage ratios D1 = (75% *Trichantera gigantea* (T) + 25% flying fish entrails (FF), D2 = 50% (T) + 50% (FF), D3 = 25% (T) + 75% (FF), and control (commercial feed). The four (4) treatments feeding trials laid-out in a completely randomized block design (CRD) replicated thrice to compare the effects on the growth performance in the fingerlings of Brackish water Enhanced Selected Tilapia (BEST). Two milliliters of cod liver oil was added to each diet to provide essential fatty acids (Mohanta *et al.*, 2008).

Dry ground ingredients in different ratios were mixed and homogenized; Cod liver oil was gradually added while mixing constantly. Processing of the feeds followed the work of SEAFDEC/AQD (Millamena *et al.,* 2002) and was analyzed for proximate composition. All formulated feeds (300g/feed samples) were packed in a microwavable plastic container and sent to the Department of Science and Technology (DOST-7 RSTL) Sulodnun Lahug, Cebu City, and were analyzed for proximate composition: crude protein, ash, moisture (NMKL), total fat (CSOP-3-007), crude fiber following the AOAC method, carbohydrates, and energy (Kcal/100g).

Experimental Procedures

Twenty-five-day-old brackish water enhanced selected tilapia (BEST) fingerlings were procured from the Bureau of Fisheries and Aquatic Resources (BFAR) Hatchery Babatngon, Leyte and transported to ESSU in oxygen-filled polyethylene bags late in the afternoon to prevent stress and mortality. A total of one hundred eighty (180) pieces of BEST fingerlings with an average weight of 3g and total lengths of 5cm were used as experimental animals. BEST fingerlings were stocked in indoor canvas tanks and acclimatized for a period of 8 days. During acclimatization, fingerlings were fed a control diet at 3% body weight twice a day (Al Amoudi *et al.*, 1996). The prevailing water salinity during acclimatization was increased up to 5 ppt. prior to stocking of experimental animals.

Fingerlings were weighed for the average body weight after acclimatization and assigned into groups of fifteen (15) fish in each experimental tank. To avoid handling stress and mortality, the initial weight of stocks was obtained by bulk weight (total weight in grams of required number of stocks per tank) using a digital weighing scale (0.01 g sensitivity). Since the experimental animals had uniform sizes, the initial length (total length inmm) of fifteen individuals was measured prior to slow release into canvas tanks measuring 1.5m x 1m x.50m with a water depth of.30m supplied with aerators to ensure a high concentration of dissolved oxygen. In measuring the total length (TL,mm), the experimental animals were measured from the tip of the snout to the caudal peduncle.

All fish per treatment were fed manually 3 times a day at equal intervals of 8:00 AM, 1:00 PM and 5:00 PM at 10% wet body weight per feeding per day. The percent distribution of feed was divided equally into 3 portions for 3 feedings. Feeding was performed by manual broadcasting prior to feeding and after aeration was adjusted to ensure that the experimental animals could easily recognize the diet given. Feces were removed in the morning and evening after 3 hours of feeding by siphoning debris from the bottom of each canvas tank.

The daily feeding rate (DFR) was determined following the formula: DFR= weight of the fish x feeding rate x total stock.

Sampling and Analysis

Sampling was performed every fifteen (15) days to determine the growth of the stocks and to adjust the daily feeding ration for the following sampling. Twenty percent (20%) of the total fish stock per treatment was obtained and sampled. Sampling was performed early in the morning by carefully collecting the stock using a scoop net, and the stock was placed in a basin with aerated water. The weights of the fish were expressed in grams, and the total length was expressed in centimeters. The total length and weight of the experimental animals were determined with the use of a *Vernier caliper* and digital weighing scale.

The following formulae were used in determining the growth parameters:

Specific growth rate (SGR)

The specific growth rate (% g/day) of the experimental stocks was computed using the formula of Millamena *et al.,* (2002):

$$\text{SGR (\%/day)} = \frac{\ln W2 - \text{In } W1}{T2 - T1} \text{ x } 100$$

where:

ln = natural logarithm

W2 = final weight (g)

W1 = initial weight (g)

T2 = end of period (days)

T1 = start of culture period (days)

Feed conversion ratio

The feed conversion ratio was calculated based on the work of Tacon (1990).

$$\text{FCR} = \frac{\text{cummulative feed given (g)}}{\text{total weight gained (g)}}$$

Survival Rate Monitoring

Total counts of stocks in each tank were performed. After a two-month culture period. The survival rate was computed using the formula:

$$\text{SR (\%)} = \frac{\text{final no. of stocks at harvest}}{\text{initial no. of stocks}}$$

The cost and return analysis was determined to obtain the feasibility or profitability of the treatments used. Returns on Investment of the four treatments were computed using the following formula of Israel (2008).

$$\text{ROI} = \frac{\text{net income}}{\text{total cost of production}} \text{ x } 100$$

All data collected were analyzed for variance (ANOVA) and tested with LSD (least significant difference) using the computer software SPSS Version 17.0. LSD was used to determine the significant difference and the range of mean differences between the means of treatments.

Results and discussion

Growth Parameters

Growth of brackish water enhanced selected tilapia (BEST) was determined by calculating the weight (g), length (mm) increments, and specific growth rate (SGR) during the sixty (60) days of culture. Table 1 presents the growth performance of stocks fed with different diets. Experimental stocks fed with Diet 2 (50% *Trichantera gigantea* + 50% Flying fish entrails) obtained the highest final weight and final body length of 63.33g and 125.1mm.

This may be attributed to the high crude protein percentage due to the 50% mixture of plant protein and 50% fishmeal. Those stocks fed with commercial feed (control) obtained a mean final weight of 51.5 g and 129.8mm, Diet 3 (25% Tri + 75% FF) with 47.67 g and 97.9mm and the least was Diet 1 (75% Tri + 25% FF) with 18.67 g and 64.5mm, respectively.

Analysis of variance (ANOVA) on the final weight increment of BEST revealed significant differences (P<.05) among the four treatments used. Further analysis using the least significant difference (LSD) test between treatments showed that Diet 2 was significantly (P<0.05) different from the control diet (commercial). Diet 3 and control diet were not significantly different (P<0.05).

This shows that among the different formulated diets used, Diet 2 is the best feed; if this feed is given to the animals, a significant increase in the weight of BEST is observed. The current study also showed that 50% fishmeal in a practical diet for BEST could be effectively replaced by the inclusion of plant-based protein (*Tricanthera gigantea*) without a reduction in growth performance.

Findings from the present study conform to the report of Bonaldo *et al.* (2015) that a mixture of plant protein (soybean and sunflower seed) and fishmeal diet up to 50% levels did not disturb the growth rate and nutrient utilization in turbot. Previous reports of Attalla *et al.* (2008) revealed that the 50% Soymeal + 50% fish meal group gained the highest weight (31.1g) after 20 weeks of Nile tilapia fry experiments.

Table 1. Analysis of growth parameters of Brackishwater Enhanced Selected Tilapia (BEST) fed with different formulated diets.

Treatment	Initial Weight (g)	Final Weight (g)	Initial Body Length (mm)	Final Body Length (mm)	SGR
Control	3.0 ± 0.05	51.5 ± 10.67^{b}	15 ± 0.1	129.8 ± 2.87^{a}	5.05 ± 0.29^{a}
Diet 1	3.0 ± 0.05	18.67 + 8.11c	15 ± 0.1	64.6 ± 3.98^{c}	2.98 ± 0.35^{b}
Diet 2	3.0 ± 0.05	63.33 ± 5.72^{a}	15 ± 0.1	125.1 ± 2.76^{a}	5.08 ± 0.15^{a}
Diet 3	3.0 ± 0.05	47.67 ± 7.61^{b}	15 ± 0.1	97.9 ± 19.9^{b}	4.57 ± 0.42^{a}

* Mean with the common letter is not significantly different at 0.05 level of significance.

Statistical analysis on the length revealed that the control diet and diet 2 had no significant differences (P<0.05) between them but none with both diet 2 and diet 3. The results show that Diet 2 (50% *Tricanthera* + 50% Flying fish entrails) was just as good as the control (commercial feed).

Growth trends in average body weight (ABW) and total body length (TBL) are shown in Figures 1 and 2.

The growth rates of BEST in all treatments generally increased. In terms of weight, stocks in diet 2 gained more weight than the rest of the treatments and were significantly different from the other treatments.

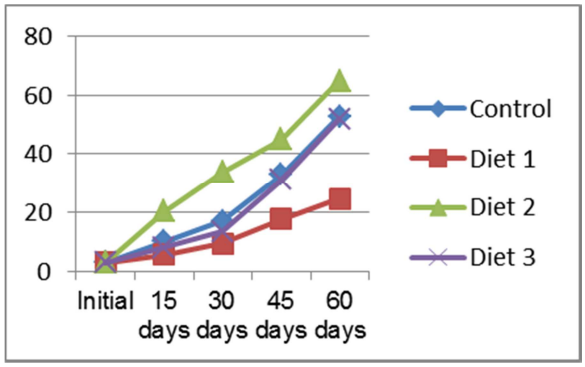

Fig. 1. Growth curve (weight) of BEST as influenced by four different feed diets.

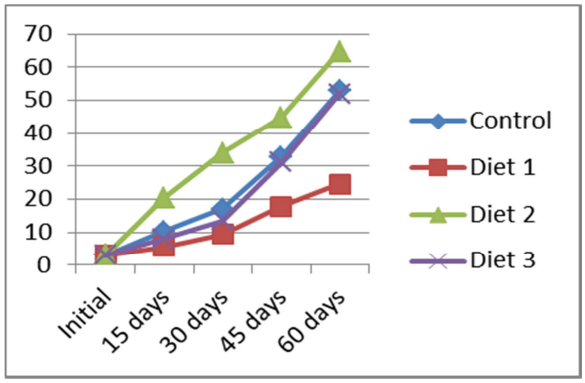

Fig. 2. Growth curve in length (mm) of BEST.

The specific growth rates (SGR) of Brackish water Enhanced Selected Tilapia (BEST) obtained in the study revealed values of 2.98g/day to 5.08g/day. BEST fed with a combination of 50% (Tri) + 50% (FF entrails) obtained the highest specific growth rate (5.08g/day), followed by stocks fed with commercial (5.05g/day). BEST fed with 75% (Tri) + 25% (FF) obtained the lowest SGR of 2.98g/day. Specifically, there is significant difference on the specific growth rate of the BEST tilapia as affected by the different formulated feeds between Control and Diet 1 (D1).

However, there is no significant difference between control and D2 and D3. Hence, in terms of specific growth rate, D2 and D3 feeds are comparable to the commercial feeds. This result is supported by the work of Bonaldo *et al.* (2015), who reported that a fishmeal combined with a mixture of plant proteins positively favors growth performance.

Survival Rates and Feed Conversion Ratio (FCR)

It can be noted that Diet 2 exhibited superior percentage survival over the rest of the treatment, which indicates that diet with a combination of 50% *Tricanthera* + 50% Flying fish entrails may have provided adequate nutrition for BEST during the culture period. The highest survival rate was seen in the Diet 2 group (93.33%), followed by the Diet 1 group (88.89%). The lowest survival was observed in the control group (81%). Percentage survival of Brakish water Enhanced Selected Tilapia (BEST) in four different formulated diets (Table 2).

Although the range of (81% - 93.33%) percentage survival of each treatment was not very close, the ANOVA results showed no significant differences among the survival BEST feed with different formulated feeds. This finding indicates that the percentage survival of BEST was comparable either fed with diet in commercial, Diet 1, 2, and 3.

Table 2. Percentage Survival and feed conversion ratio of BEST as influenced by different diet.

	Treatment			
	Control	D1	D2	D3
Initial Stocks	45	45	45	45
Final Stocks Recovered	36	40	42	38
% Survival	81	89	93	84
FCR	1.08	1.22	1.17	1.11

Comparing the FCR after the 60-day culture period within the four diet FCR values, the optimal FCR was 1.08 obtained by stocks fed the commercial diet because less feed is needed to convert fish flesh. Experimental stocks given with 75% *Tricanthera* + 25% Flying fish entrails (Diet 1) had a greater amount of feed due to the higher FCR computed at 1.22. FCR is a very important indicator in the profitability of aquaculture operations because it measures the efficiency of the given feeds that are converted into fish biomass.

FCR values obtained however revealed that there was no significant different on the FCR of the Brackish water Enhanced Selected Tilapia (BEST) with the four formulations. This finding implies that all formulated feeds had the same performance with the commercial feeds in terms of feed conversion ratio. For most species, FCRs of 1.5 – 2.0 are considered "good growth" (Aderolu, 2010). The present study obtained better FCR values ranging from 1.08 – 1.22 than the study of Al-Thobiati *et al.* (2016), in which FCR values ranged from 2.06-3.68 in fish fed diet A, 1.95 -2.58, etc. All formulated feeds were prepared with 40% CP for an 8-week culture period.

Proximate Analysis

Three of the diets were tested: Diets 1, 2, and 3. For the control (commercial diet), the proximate analysis was emphasized based on the product label.

Table 3 shows that among the formulated feeds, the control diet had the highest crude protein content of 40%, followed by Diet 3 (30.9%) and Diet 2 (19.60%), and Diet 1 had the lowest crude protein content (15.8%). For gross energy, Diet 2 had the highest (373 kcal/100 g); the lowest was Diet 1 (320kcal/100g). Moisture was highest in the Control diet (12%); Diet 2 had the lowest moisture content at 1.72%. For crude fiber, Diet 1 had the highest at 8.27%; Diet 2 had the lowest (4.19%). It can be noted that of the two protein sources, flying fish entrails contribute more to moisture, crude protein and crude fat in the mixtures. On the other hand, *Tricanthera gigantea* contributed more to crude fiber, ash, and carbohydrates. This implies that among the different formulated diets used, 50% *Trichantera* + 50% Flying fish entrails is the best feed; if this feed is given to the animals, a significant increase in the weight of BEST is observed. In terms of gain in length and SGR, the control diet (commercial) and Diets 2 and 3 showed no significant difference. A 20% crude protein (CP) is just enough for Brackish water Enhanced Selected Tilapia (BEST). Clark *et al.* (1990) investigated the protein

requirement of Florida red tilapia reared in seawater pools to determine the performance and survival of fish fed isocaloric diets containing 20, 25, and 35% CP and obtained no significant differences for both criteria. This demonstrates the feasibility of lowering feed cost by using low-protein diets without reducing fish performance.

Table 3. Proximate Analysis of Feeds.

	Control	D1	D2	D3
Ash (%)	10.0	16.3	8.75	11.7
Moisture (%)	12.0	5.42	1.72	10.3
Total fat (%)	6.0	1.36	2.52	2.22
Crude protein	40.0	15.8	30.9	19.6
Carbohydrates	-	61.5	56.6	56.2
Kcal/100g	-	320	373	323
Crude fiber (%)	7.0	8.27	4.19	5.92

Source: D1 to D3 (Q.R.S, and FNRI DOST-7) and Control – (from the product label of commercial feed)

Table 4. Projected Cost and Return Analysis of (BEST) as influenced by different formulated diets after two months culture period.

Item	Control (Php)	D1 (Php)	D2 (Php)	D3 (Php)
Sales	1,080.00	960.00	1,320.00	1,260.00
Less:				
A. Variable Costs				
Fingerlings	11.25	11.25	11.25	11.25
Feeds	64.00	81.40	48.00	53.15
B. Total Fixed Costs	845.00	845.00	845.00	845.00
Depreciation				
Total Income	920.25	937.65	904.25	909.40
Net Income	159.75	22.35	415.45	350.60
Return on Investment (%)	17.35	2.38	46.00	39.00

Cost and Return Analysis

The cost and return analysis for the four diets and income highlights are shown in Table 4. The current maximum price of tilapia was also used as the basis in calculating gross revenues. The expenses incurred during the culture period consisted of canvas tanks, fingerlings, and feeds. Overall, the results showed that among the test diets, the highest net income was computed in Diet 2 amounting to Php 415.45, followed by Diet 3 at Php 350.60, and the lowest was in Diet 1 at Php 2.38. Based on the return on investment (ROI), it can be noted that Diet 2 (50% Tri + 50% FF) has the highest returns computed at 46%, which means that for every peso invested, there is a corresponding gain of 46 centavos. Diet 3 (25% Tri and 75% FF) has a 39% return on investment, while Commercial feed and Diet 1 (75% T and 25% FF) have very much lower ROI, with only 17.35% and 2.38, respectively. Overall, the findings showed that cost and return analysis of Brackish water enhanced Selected Tilapia (BEST) fed with 50% *Tricanthera* + 50% Flying fish entrails is more economical than those fed with commercial and the rest of the diets. This result is supported by the work of Nguyen *et al.* (1999) using leaves of *Trichantera gigantea*, which are offered fresh to pigs, replacing approximately 30% of the required commercial diet. Thus, there was substantial savings in feed cost with no reduction in the growth performance of the animal.

Conclusions

Growth in terms of gain in weight and specific growth rate of Brackish water Enhanced Selected Tilapia (BEST) fed with 50% *Tricanthera* + 50% Flying fish entrails were significantly better than the other three formulated diet. In terms of gain in length, 50% *Tricanthera* + 50% Flying fish entrails was just as good as commercial diet. A 20% crude protein (CP) is just enough for Brackish water Enhanced Selected Tilapia (BEST).

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