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Exploring the Possibility of Dietary inclusion of Vegetable Waste in the Feed of Nile Tilapia, *Oreochromis niloticus*

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Abstract

Aquaculture is the fastest growing food production sector in the world and Tilapia is a major species contributing to the freshwater aquaculture production. Further expansion of aquaculture demands an adequate supply of efficient, nutritious and inexpensive fish feed because feed contributes significantly to the cost and efficiency of fish production. It is estimated that feed costs can account for up to 70% of the total operating cost in aquaculture. Fish nutritionists all over the world are trying to develop cost effective feeds without compromising on the efficacy towards claiming better production levels thus by increasing the profitability. It is a fact that waste generation is a major problem in the vegetable production and marketing sector. The volume of wastes generated and its resultant environmental impacts necessitate the need of utilizing these wastes effectively. Developing cost effective fish feeds from the vegetable wastes have great relevance at present. The current study aims at the utilization of vegetable wastes in the feeds for Nile tilapia, which is a popular species in freshwater aquaculture. The possibility of incorporating vegetable waste in the fish feed was tried through an indoor study in the species comparing the test diets against the fish meal based and clam meal based control feeds. The experimental diet was formulated keeping the overall protein content at 30%. Feeding was done @5% of the body weight per day. Proximate composition of vegetable waste, test diet and the carcass was recorded during the study. FCR, FCE, SGR and % survival were also recorded. Most important water quality parameters were checked on a daily basis and the other factors were analyzed fortnightly. There was significant reduction (P<0.05level) in the weight and length attained by the fish fed with the test diet during the experimental period of 90 days. Organoletptic quality of the raw fish and boiled fish after the rearing period was assessed using Hedonic Scale Scoring method. The results of the study indicate that there is a possibility of incorporating vegetable wastes in the Tilapia-feed though it does not perform as good as the other expensive feeds with fish meal and clam meal. But while considering the cost factor, the inclusion of vegetable waste has real sense. More nutritional studies are warranted in this line especially using other herbivorous fishes like Indian Major Carps towards attaining concordant results.

Keywords: Tilapia, growth, vegetable waste, nutrients, quality of flesh.

Introduction

Tilapia is one of the most important farmed fish species and its production continues to increase at an accelerated rate[1]. However, since the price of feed may account for an important percentage of the production costs of tilapia farms[2] an important challenge faced by the tilapia industry is the development of cost-effective feed. Rapid expansion of fish culture in recent years demands the development of nutritious fish feeds, as well as better feed utilization, due to the fact that feed cost may influence the overall production cost by 50-80%. As the global production continues to grow, so too does the world's need for food, especially for the sources of high quality protein[3]. With the world population currently over 7 billion, and forecasts exceeding 8 billion by the year 2030, the consumption of seafood at that time is predicted to reach between 150-160 million tonnes[4]. However, because of the decline in wild fish catches in a large part due to the unsustainability of industrialized fishing, aquaculture will be called upon to fill this gap.

Fish meal is an integral component in aquaculture diets due to its multiple nutritional benefits. Fish meal is very palatable and has exceptional nutritional value including an excellent balance of essential amino acids and essential fatty acids, which closely meet the requirements of most farmed fish and also provides an excellent sources of digestible energy and vitamins[5]. Fish meal as a protein source for commercial fish feeds has become scarce and expensive due to fluctuations in supply and quality. Therefore, a variety of protein sources of both plant as well as animal origin have been tested. Among all the plant protein sources tested, soybean meal has been the most popular ingredient tested to substitute fish meal partially or completely in diets of various fish species[6].

India's economy and livelihood is closely linked with agriculture as nearly 70% of the population is concentrated in the rural areas. As a result, vegetable wastes are produced in large quantities. In India, this constitutes to the tune of around 5.6 million tons annually. Vegetable processing industries are incriminated for high levels of pollution; hence it is becoming very crucial to solve this problem by developing optimized systems for the treatment of vegetable wastes.

Culture of tilapia is gaining importance in South East Asian countries due to its fast growth rate under high stocking densities in ponds. In India also, there is good scope for tilapia as it fetches higher market price compared to carps. The dietary formulation of a nutritionally balanced diet to meet the protein requirement is one of the major aspects in the development of aquaculture practices. Realizing the importance of the fish species introduced to India and their popularity as alternative candidate species for fresh water aquaculture, the present investigation has been designed to assess the possibility of utilizing vegetable waste in feeds for Tilapia.

Material and Methods

Experimental fish and feeding trials: The study was conducted indoors in cement cisterns of 300 l capacity over a period of 90 days. The fry of Tilapia were procured locally and transported to the wet lab of Kerala University of Fisheries and Ocean Studies, Panangad in oxygen packing. The fry were acclimatized to the culture conditions for a period of two weeks prior to commencement of the experiment. The fishes were kept in an oval, flat bottom cement tank of 500 litre capacity for acclimatization. The tank was half filled with fresh water and provided with gentle aeration. The fry were fed with commercially available pelleted feed. No water exchange was done during acclimatization. After 14 days, the fry were transferred to experimental tanks. Fry of the Tilapia were stocked @ 10 no. per cistern. Feeding was done @ 5 % of the bodyweight on a daily basis. Each feed was tried in triplicate. Sampling was done at fortnightly intervals to assess fish growth as well as variation in water quality parameters over the experimental period. Standard procedures[7] were followed for assessment of water quality parameters on termination of the experiment. The surviving fishes were collected and the length and weight recorded. The harvested fish in raw as well as cooked form were assessed for sensory characteristics adopting Scoring method using Hedonic Scale.

Experimental diet preparation: The ingredients used for feed formulation were rice bran, ground nut oilcake, fish meal / clam meal / vegetable waste, wheat flour and vitamin mineral mixture. All the feed ingredients were obtained locally, dried where necessary, powdered, sieved and stored in airtight containers for use. Vegetable waste was chopped, steamed, mashed, dried and powdered for incorporation in feeds. The quantity of individual ingredients required to formulate a kg of diet was worked out using Pearson's Square method to balance protein and energy levels are shown in the table 1. All the weighed ingredients were mixed thoroughly in a pulveriser. Subsequently, all the ingredients were hand mixed with sufficient quantity of water to form smooth dough. The dough was then cooked under pressure for about 15 minutes. The cooked dough was then cooled, vitamin mineral mixture added and mixed thoroughly, to ensure uniform dispersion, and pelletised using a hand pelletiser with 2mm die. The pellets thus formed were oven dried at 70^0C to a moisture content of less than 10%. All the experimental diets were prepared containing 30% of protein.

Proximate composition: The proximate composition of three diets were analysed following the procedures recommended by AOAC (1990)[8].

Nutritional evaluation of experimental diet: The growth rate in terms of specific growth rate (%), food conversion ratio (FCR), Feed conversion efficiency (FCE) and Survival were calculated by following the standard procedures which are as follows:

Percentage of specific growth rate=

$$\frac{(\log_e \text{ Final body weight} - \log_e \text{ Initial body weight})}{\text{Total no. of experimental days}} x100$$

Food conversion ratio= $\dfrac{\text{Total dry food intake(g)}}{\text{Total live weight gain(g)}}$

Feed conversion Efficiency = $\dfrac{\text{Gain in weight (g)}}{\text{Food intake (g)}}$

Survival rate =
The survival rate of fishes is expressed in terms of percentage. This was calculated as follows:

$$\text{Survival (\%)} = \frac{\text{Final Number}}{\text{Initial Number}} \times 100$$

Statistical analysis: The experiment was designed in Completely Randomized Design with three replications for each treatment. Organoleptic quality of raw fish and boiled fish was statistically analysed employing Non-parametric, Independent-Sample Kruskal-Wallis Test.

Results and Discussion

Water quality parameters: Average of the water quality parameters from the experimental units like temperature, pH, dissolved oxygen, total alkalinity, ammonia, nitrite and nitrate were analysed adopting the standard procedures[7]. The water quality parameters measured in different treatments in laboratory conditions during the experimental period registered a more or less similar trend and all of them were in acceptable range for fish culture. The study revealed that average temperature ranged between 27 to 28^0C, pH 6 to 7, Dissolved oxygen 5 to 5.5mg/l, alkalinity 80 to 120 mg/l, ammonia 0.00-0.02, nitrite 0.1- 0.2mg/l and nitrate 0.4-1.2mg/l all throughout the experimental period see in the table 2 and 3. Yigit and Olmez (2009)[9] attempted to study the substitution of fish meal with canola meal as an alternate protein source for fry of

Oreochromis niloticus under laboratory conditions. The study reveals that water temperature of 27±2^{0}C, dissolved oxygen level of 6.57±0.05 mg/l and pH values of 7.2± 0.2 are optimum for growth and survival of tilapia. Similar results have also been recorded for tilapia by several authors[10-13].

Effect of different diets on Growth parameters of Nile Tilapia: Results in table 4 revealed that initial weight of Nile tilapia at the start of the experiment were averaged at 0.77 (Fish meal based diet), 0.79 (clam meal based diet) and 0.64 g (vegetable waste diet) respectively. Averages of final weight at the end of the experimental period were 12.29 (fish meal based diet), 13.01 (clam meal based diet) and 9.29g (vegetable waste diet) respectively. Average SGR in Nile tilapia diets were 3.08 (fish meal based diet), 3.12 (clam meal based diet) and 2.97% (vegetable waste diet) respectively. The present study revealed that clam meal based feed gave higher growth as compared to fish meal based diet and vegetable waste diet. Yigit and Olmez[9] utilized canola meal to replace fish meal as an alternative protein source in diets for fry of Nile tilapia reveals that protein from canola meal can replace up to 10% of protein from fish meal in diets for tilapia fry. The study also indicates an inverse relationship between growth of tilapia and higher dietary level of canola meal beyond 20% substitution level. Kanazawa *et al.*[14] reported that fresh short necked clam gave superior growth compared to the other compounded diet for *Penaeus japonicus.*

Survival rate: Survival is an important factor in fish production. The survival of fish depends on availability and type of feed, physio-chemical conditions of water *etc*. The survival rate of Tilapia was 100% in all the experimental treatments are shown in the table 4. The survival rate was about 100% in cemented cisterns found by Haroon and Hossain (2001)[15] and 94%-96% in earthen ponds as reported by Maniruzzaman (2001)[16]. So, the survival rate was found not to be influenced by different diets.

Feed utilization parameters: In the present study, varying FCRs were obtained with different diets having different ingredients for the feed of fry. Low feed conversion ratio in clam meal based feed reflects that these diets were utilized more efficiently shown in the table 4. Siddiqui *et al.*[17] and AlHafedh[18] have reported that FCR values decreases with increasing protein levels. Table 4 also revealed that clam meal based feed has shown highest FCE compared to fish meal based and vegetable waste based feeds. Venkataramiah *et al.*[19] observed an increase in FCE, when vegetable matter was increased in the diet. However, diets with plant proteins were found to give relatively higher FCR and a lower FCE, than those with animal proteins. These findings agreed with the present study. Table 5 depicts the proximate composition of feed ingredients. Table 6 and 7 show the proximate composition of test diets and carcass respectively.

Organoleptic qualities/ sensory evaluation of Tilapia: In the present study, Organoleptic qualities of raw tilapia fillet with respect to odour and texture remained non-significant (P >0.05) in all the treatments. The colour, odour and texture remained non-significant in the case of cooked fish. However, colour in raw Tilapia and taste in cooked Tilapia were significantly different (p<0.05) among the treatments are shown in the table 8 and 9. Nutritional quality and organoleptic acceptability in terms of colour, texture, smell, flavour and appearance may be affected by the environmental degradation and quality of feed provided during the culture especially in semi-intensive and intensive culture systems compared to wild fish [20,21].

Table-1
Proportion of the ingredients in various test diets (in%)

Ingredient	Fish meal	Clam meal	Vegetable waste
Fish meal	25.6	Nil	Nil
Clam meal	Nil	24.35	Nil
Vegetable waste	Nil	Nil	13.8
Rice bran	24.4	25.65	13.8
Wheat flour	24.4	25.65	13.8
Ground nut oil cake	25.6	24.35	58.6
Vitamin and mineral mix	1	1	1

Table-2
Ranges of water quality parameters in the experimental tanks over the period of study

Temperature	pH value	DO_2 ppm	Alkalinity mg/1	Ammonia mg/1	Nitrite mg/1	Nitrate mg/l
27-28	6-7	5-5.5	80-120	0.00-0.02	0.1-0.2	0.4-1.2

Table-3
Average of water quality parameters in various treatments

Treatments	Temperature	pH	DO_2	Alkalinity	Ammonia	Nitrite	Nitrate
T0 (Fish meal based diet)	27.0	6.9	5.3	120	0.01	0.3	1.1
T1(Clam meal based diet)	29.0	7.1	4.1	124	0.00	0.2	0.8
T2(Vegetable waste based diet)	27.8	7.3	5.3	125	0.01	0.4	0.4

Table-4
Growth Parameters

Sl. No.	Growth Parameters	T_0(Fish meal based diet)	T_1(clam meal based diet)	T_2(vegetable waste diet)
1.	Initial Weight (g)	0.77±0.11	0.79±0.11	0.64 ± 0.06
2.	Initial Length (cm)	2.9± 0.2	2.5 ± 0.3	2.6 ± 0.2
3.	Final weight (g)	12.29 ± 0.31	13.01 ± 0.33	9.29 ± 0.13
4.	Final length (cm)	8.8 ± 0.1	10.3 ± 0.8	6.6 ± 0.4
7.	Food Conversion Ratio (FCR)	1.86 ± 0.03	1.80 ± 0.06	2.01 ± 0.07
9.	Specific growth rate (%)	3.08 ± 0.14	3.12 ± 0.25	2.97 ± 0.10
10	Feed conversion Efficiency %	53.0	55.0	49.0
11.	Survival%	100 ± 0.00	100± 0.00	100±0.00

Table-5
Proximate composition of ingredients

Ingredients	Proximate composition				
	Moisture	Crude Protein	Crude Fat	Total Ash	Crude Fibre
Deoiled rice bran	9.71	13.12	1.83	14.77	12.27
Ground nut oil cake	10.83	42.00	16.11	9.44	7.74
Wheat flour	11.0	10.06	3.5	12.6	11.5
Clam meal	7.0	56.8	11.6	12.4	5.5
Fish meal	8.6	53.06	9.1	18.5	20.4
Vegetable waste	7.2	15.75	2.15	11.25	8.42

Table-6
Proximate composition of the test diets

Feeds	Proximate composition				
	Moisture	Crude protein	Crude fat	Total ash	Crude fibre
T0(Fish meal based feed)	11	30	9	12	11
T1(Clam meal based feed)	6.0	30.6	9.5	10.7	7.8
T2(Vegetable waste feed)	8.17	29.06	7.47	14.77	9.7

Table-7
Proximate composition of the carcass (on wet basis)

Carcass (Treatment wise)	Proximate composition				
	Crude protein	Crude fat	Total ash	Crude fibre	Moisture
Initial Proximate					
	10.01	1.45	1.9	1.6	79.1
Final Proximate					
T0(Fish meal based feed)	14.5	2.48	2.1	1.65	79.6
T1(Clam meal based feed)	14.7	2.49	2.0	1.72	80.6
T2(Vegetable waste feed)	14.1	2.35	2.0	1.7	80.8

Table-8
Non- Parametric, Independent-Sample Kruskal-Wallis Test for raw Tilapia fillet

Characteristics	Degrees of freedom	N	Test Statistics	Sig
Colour	2	30	7.078	0.029*
Odour	2	30	5.304	0.070**
Texture	2	30	5.181	0.075 **

*Significance (P<0.05) ** Non- Significance (P>0.05)

Table-9
Non- Parametric, Independent-Sample Kruskal-Wallis Test for cooked Tilapia fillet

Quality Characteristics	Degrees of freedom	N	Test Statistics	Sig
Colour	2	30	1.185	0.454**
Odour	2	30	1.999	0.368**
Texture	2	30	0.882	0.643**
Taste	2	30	15.133	0.001*

*Significance (P<0.05) ** Non- Significance (P>0.05)

Conclusion

The current study throws light on the possibility of utilizing vegetable waste as an efficient substitute for other expensive feed ingredients which will influence the cost of fish culture operation. Among all the experimental diets, clam meal was observed as a more quickly acceptable feed, compared to the other feeds. The cost involved in using vegetable waste as a dietary component is negligible, besides it is easily available and that too in bulk quantities. A possible disadvantage of vegetable waste can be related to the digestibility aspect, which could be enhanced by resorting to techniques like ensilation. But while considering the cost factor, the inclusion of vegetable waste has real sense. More nutritional studies are warranted in this line, especially using other herbivorous fishes like Indian Major Carps towards attaining concordant results.

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