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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (19): 3248-3253, 2007
ISSN 1028-8880

Extruded Leftover Food as Animal Feed: I. Effect of Extruded Feed on Growth and Feed Utilization of Tilapia (*Oreochromis niloticus*) in Saudi Arabia

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Abstract: A Laboratory experiment was used to evaluate the effect of extruded leftover food as an alternate source of fish diet to Nile tilapia (*Oreochromis niloticus*, 76.75±1.27 g). Three experimental diets were used. Two extruded leftover food types [with minerals and vitamins (type-1) and without (type-2) were used to prepare two experimental treatments in duplicate as compared to a commercial tilapia diet (ARASCO) as a control. The final body weight and Specific Growth Rate (SGR) were not affected by different types of leftover feed. Whereas, the Feed Conversion Ratio (FCR) and the Protein Efficiency Ratio (PER) were significantly affected by the different feeds. The highest significant values of FCR was shown for fish fed with extruded leftover feed without premix, while Nile tilapia fed with control diet recorded the highest values of PER. The present study showed that the extruded leftover food could be used to prepare least cost diet for Nile tilapia.

Key words: Leftover food, extrusion technique, Nile tilapia, feed conversion ratio, growth, protein efficiency ratio, protein-retention

INTRODUCTION

Fish farming is growing in the Kingdom of Saudi Arabia due to the incentives by the government in the form of interest free loan, subsidized feed and free fish spawns. Domestic demand for fresh fish is also increasing due to the value of fish as a healthy food especially as a source of cholesterol free food which has been found to reduce the risk of cardiovascular diseases (FAO, 2002). The growing demand of fish feed for aquaculture expansion has compelled the scientists to look into the possibility for including different kinds of feed ingredients, which are easily available at lower price. Lack of nutritionally adequate and low cost feed has always been one of the major constraints to the successful aquaculture business in many developing countries.

In order to mass-produce of cultivable fish species under an intensive system in a country like Saudi Arabia, there is a need to formulate low cost fish feed using locally available different feed ingredients. Intensification of Nile tilapia culture in Saudi Arabia has made it essential to develop suitable fish feed for use either as a supplementary feed in ponds or as a complete diet in tanks. For economic and practical reasons, the fish diets must use locally available feed ingredients preferably those unsuitable for direct human consumption. Hinty and Siddiqui (1993) reported that the available commercial fish feed in the local market neither meets in terms of quality nor particle size.

Rodriguez *et al.* (1996) reported that animal by product meal can be used as a sole protein source in commercial feed for tilapia fry without affecting growth and food utilization. Belal and Al-Dosari (1999) observed that tilapia growth did not differ ($p<0.05$) for fish fed diets in which 0, 20 and 40% of the fish meal in diet was replaced with salicornia meal. In the past, interest was shown in the use of domestic waste as animal feed (Spoelstra and Tajook, 1984). Similarly, Steg (1984) showed that by-products and wastes were used for feeding purposes in Netherlands for the development of economical feeds. Olli *et al.* (1995) found that fish fed the diet containing 20% soybean protein grew as well as fish fed with high-quality fish meal as the sole protein source, while the fish fed on the diet containing 40% soybean protein grew significantly less. Nandeesha *et al.* (1995) used three mixed feeding namely A: used a plant-based low protein (16%-diet A), B: two fish meal-based diets of 26% protein (diet B) and 31% protein (diet C). They concluded that fish growth on diet A grew least, while there was no significant difference between those fed on diets B or C. Belal (1999) concluded that 20% fish meal can be supplemented with barley seeds in Nile tilapia feed without compromising growth. But the incorporation of leftover food in animal feed has not been done so far and needs to be extensively studied. Such information will be of paramount importance in the assessment of the economical use of inexpensive dietary nutrient sources in extruded fish feed.

Recently, Samocha *et al.* (2004) used a co-extruded soybean poultry by-product with egg supplement as a substitute for fish meal in a practical diet formulated to contain 32% crude protein and 8% lipid. They found at the growth rate trial that survival, final weight, percent weight gain and Feed Efficiency (FE) were not significantly different among treatments. Co-extruded soybean poultry by-product meal with egg supplement appears suitable as a substitute for fish meal in *L. vannamei* diets. Considerable attention has been devoted to the evaluation of plant protein such a soybean meal (Lim and Dominy, 1990; Pieda-Pascual *et al.*, 1990; Tidwell *et al.*, 1993; Sudaryono *et al.*, 1995; Gatlin III *et al.*, 2007), solvent extracted cottonseed meal (Lim, 1996), lupin meals (Sudaryono *et al.*, 1999), various legumes (cowpea, green mongbean, rice bean), leaf meals (Eusebio, 1991; Eusebio and Coloso, 1998) and papaya or camote leaf meal) (Penaflorida, 1995) as ingredients in feeds of aquatic animals. Because of their low price and consistent quality, plant proteins are often economically and nutritionally viable source of protein. Schulz *et al.* (2007) showed that inclusion of 30% protein from pea protein isolate resulted in a growth performance (in terms of WG and SGR) that did not differ significantly from diet 100/0 in contrast to fish fed diet 55/45 and 40/60. However, due to potential problems associated with insufficient levels of indispensable amino acids (e.g., lysine and methionine), anti-nutritional factors and poor palatability, commercial use is often limited. Considerable research has been conducted to evaluate the suitability of various feed ingredients as alternative protein sources for fish meal (Tacon and Akiyama, 1997). Chewman *et al.* (2005) found that the efficiency of feed conversion in fish is much higher as compared to traditional live stocks. However, fish feed requires very different physical and functional properties compared to other animal feeds. These are generally achieved through extrusion techniques. Middlehon and Ferket (2001) stated that feed is the principal operating cost in finfish, alternative ingredients that reduce feed costs yet maintain adequate levels of growth and production can have a marked impact on the profitability of the industry. Recent technological advances have made it possible for many agricultural waste products to be recycled into feeding ingredients.

The Kingdom of Saudi Arabia is actively promoting an ambitious food self sufficiency program and provides financial incentives to the concerned sectors. Such encouragement led to 88% self sufficiency in vegetables, 68% in broiler chicken, 66% in fruit and 46% in red meat. The government is also encouraging local framers to diversify into poultry and fish farming besides the livestock (sheep and camels) and dairy production (Hinty and Siddiqui, 1993). They also emphasized the improvement of quality by increasing the pellet holding time on water surface, particle size and protein percentage. Also they recommended the utilization of locally available low cost fish feed ingredients from the by products of food and dairy industries. Daily leftover food in the restaurants, cafeterias and bakeries of Riyadh city is abundant and considered as waste food. Besides, large quantities of feed or feed ingredients are imported to feed animal on regular basis. In 1997 Saudi Arabia was the largest importer of barley of five million metric tons to feed poultry (Anonymous, 2000). Poultry and fish farming are growing rapidly in Saudi Arabia which requires sustainable low cost feed resource management. Incorporation of different plant and animal protein sources such as fish meal, soybean and canola oil cakes have been reported by Mohsin and Jauncey (1989), Olvera *et al.* (1990), Rodfiguez *et al.* (1996) and Sadiku and Jauncey (1995), but incorporation of leftover food (waste food) as animal feed ingredient needs to be studied extensively by using the modern technique of feed processing called the extrusion technique. Such information will assess the economical use of inexpensive dietary nutrient sources in the extruded feed for fish, chicken and other farmed animals. Feed availability is one of the major operating costs for fish culture and the reduction in feed cost would naturally result in more gain in terms of cost-benefit ratio. Therefore, this study was conducted to determine the feasibility of utilizing the leftover food (waste food collected from city of Riyadh) as an economically fish feed by the extrusion technique.

MATERIALS AND METHODS

The study was carried out at the Nutrition Laboratory, Biological Resources Program, Natural Resources and Environment Research Institute, King Abdulaziz City for Science and Technology during 2005.

Survey and collection of feed ingredients: In order to utilize the waste food from city of Riyadh, several surveys were performed. The leftover food was collected from different bakeries and the fish market and evaluated for utilization as animal feed ingredients. Apart from these, cooked rice was also collected from restaurants but, due to high oil contents, the extrusion was not successfully performed. In order to overcome this problem, the leftover cooked rice were washed with hot water to remove extra fat to make the extrusion process easy and practical.

Processing of collected waste food: Two types of leftover food (waste food) namely bread (different bakeries) and the waste fish (local fish market) were collected and processed. Bread and the waste fish were dried in a forced convection oven (Advantec, FG-220 Japan) at 65°C for 24 h, then crushed into smaller pieces and ground to

powder using a grinder (Molino M-06, Italy). The fine powder was sieved through a Fisher Brand sieve No. 14 (1.4 mm) size. Proximate analysis was performed to scan out the suitability of each of these waste food items as a source of nutrient in the desired final feed product. Chemical composition of leftover food (on dry-weight basis) is presented in Table 1. Two iso-nitrogenous and iso-caloric experimental feed containing fish meal, bread flour, corn flour with and without vitamin and the mineral premix were prepared using the extrusion technique. The formulation of two experimental feed is shown in Table 2.

Mixture preparation and extrusion: Two different types of mixtures were prepared by including fishmeal and bread flour with and without minerals and vitamin premix. Besides the essential ingredients like fishmeal and bread flour, corn flour (local product) was also added in the mixture to give more fluffy texture to the extruded pellets for increasing the floating time. To achieve desired product, the extruder was calibrated and optimized by adjusting its different mechanical parameters at optimum value. The mixture was then extruded using a twin screw extruder (Model MPF19:25, APV-Baker UK) by setting the barrel temperature at 100, 120, 140 and 160°C, moisture 10% and main drive speed 300 rpm. The extruded product was cooled down at room temperature and packed in polyethylene bags and stored at room temperature. Mean chemical composition of experimental feeds is given in Table 3. Since the extruded feed was free of any type of fat, thus it was supplemented with palm oil to achieve the desired crude fat contents up to 8% after extrusion. Gatlin III *et al.* (2007) incorporated lipid supplements in aqua feeds to achieve proper fatty acid profiles to meet the metabolic requirements of fish.

Table 1: Chemical Composition of Leftover Food (on Dry-Weight Basis)

Feed type	Crude protein (%)	Fat (%)	Ash (%)	Calories (Cal)
Bread flour	13.01	1.15	0.69	62.39
Coru flour	9.14	3.40	1.30	67.16
Fishmeal	83.75	5.41	6.33	319.97
Rice flour	3.06	13.63	3.73	134.91

Table 2: Formulation of two experimental feed fed to Nile tilapia

Feed type	Fish meal (%)	Bread flour (%)	Coru flour (%)	Oil (%)	Premix (%)
Feed with premix*	32	51	8	8	1
Feed without premix	32	52	8	8	-

*: Premix: Vitamins A 2000000 IU kg, D 300000 IU kg, E 40000 IU kg, C 60000 mg kg, K-1200 mg kg, B1-4000 mg kg, B2-4000 mg kg, B6-2400 mg kg, B12-10 mg kg, Niacin-24000 mg kg, Folic Acid-800 mg kg, Pantothnic Acid-5000 mg kg, Biotin-200 mg kg, Antioxidant-20000 mg kg
Minerals: Cobalt 200 ppm, Copper 1000 ppm, Manganese 15000 ppm, Selenium, 20 ppm and Zinc 15000 ppm

Water stability test: Water stability test was performed for the extruded feed and the commercial ARASCO feed (as a control treatment) by placing the feed pellets on water surface. About 70% of ARASCO feed pellets settled down in the bottom of the beaker within 10 h, whereas the extruded feed remained floated for more than 24 h in glass beakers.

Experimental trial of prepared feed: To determine the growth performance of Nile tilapia (*Oreochromis niloticus*), a feeding trial was conducted by feeding fish on the extruded feed and the commercial ARASCO feed (control treatment).

Nile tilapia fish (*Oreochromis niloticus*) of an average weight of 76.75±1.27 g were obtained from the hatchery of King Abdulaziz City for Science and Technology, Research Station at Dirab. The fish were acclimatized for three weeks under laboratory conditions. During the period of acclimatization, the fish were fed on the same feed (ARASCO) on which it was kept at hatchery. Fifty four fish were randomly distributed in aquariums in triplicate containing six fish in each. Each aquarium was filled with 100 L of tap water and connected with a filter (Aqua Clear filter-300, Italy). Water temperature was maintained at room temperature with thermostatically controlled heaters (Thermal Compact-200W, Italy).

Due to accumulation of excretory and waste food, sponge filter media was frequently clogged which was cleaned with tap water at a weekly interval. An average temperature of 25±0.5°C was maintained in each aquarium. These facilities are fully air conditioned to maintain the desired temperature during the experiment. After the acclimatization period, ten fish were sacrificed, ground and homogenized samples were stored at 30°C for later analysis. Fish were fed on two types of extruded feed and a commercial ARASCO feed (control treatment) at the rate of 3% body weight. Daily ration was equally divided into two halves and offered at 8:30 and 2:30 h. Total fish

Table 3: Mean chemical composition of experimental feeds

Feed type	Dry matter (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Organic matter (%)	Nitrogen free extract
ARSCO	95.11	33.90	7.10	8.89	2.71	86.22	42.51
Extruded Feed (+P)*	95.36	33.87	8.34	3.08	0.52	92.28	46.99
Extruded Feed (-P)**	95.06	33.85	7.95	2.54	0.39	92.52	50.33

(+P)* means with premix; (–P)** means without premix

weight and average weight gain was recorded at weekly intervals and the daily ration was adjusted to 3% of the total body weight gain.

Daily feed intake and fortnightly weight gain were recorded and the quantity of feed consumed was adjusted accordingly. The experiment was conducted under an artificial light condition for 8 weeks where 12:12 h light and dark period was maintained, respectively. After the termination of experiment, all the fish were killed and their body length and body weight were recorded. Later on, fish were cut into small pieces and minced through a meat mincer. The homogenized samples were immediately preserved at 30°C for proximate composition analysis by following the methods of Association of Official Analytical Chemists (AOAC, 1995). The gross energy content of fish and the feed was analyzed with bomb calorimeter (PARR-Bomb Calorimeter, Model-1261, US). The growth performance parameters such as Feed Conversion Ratio (FCR), Specific Growth Rate (SGR), Protein Efficiency Ratio (PER) and Net Protein Retention (NPR) were calculated as follows:

FCR = Feed dry matter consumed (g)/Live weight gain (g).
SGR = 100[{In final weight (g)-In initial weight (g)}/time (days)].
PER = Live weight gain (g)/protein consumed (g).
PR = [Carcass protein gain/protein fed]×100.

RESULTS AND DISCUSSION

Fish body weight: Mean fish body weight ranged between 129.17 and 145.42 g fed on different experimental feed (Table 4). There was no significant difference in the fish body weight fed on different diets ($LSD_{.05}$ = 28.325). But there was a decreasing trend in fish bodyweight fed with ARASCO feed (commercial feed) as compared to the extruded feed with and without premix. This shows that the extruded feed (prepared from leftover food) was equally good in obtaining sizeable fish growth when compared to the commercial feed (ARASCO). The results agree with those of Rodriguez *et al.* (1996) who concluded that animal by-product meal can be used as a sole protein source in commercial feed for Tilapia fry without affecting growth and food utilization. Similarly, Samocha *et al.* (2004) stated that the survival, final weight and Feed Efficiency (FE) were not significantly different when co-extruded soybean poultry by-product with egg supplement was substituted for fish feed meal in a practical diet formulated to contain 32% crude protein and 8% lipid.

Table 4: Effect of different feed types on body weight, FCR and SGR of Nile tilapia

Feed type	Body weight (g)	FCR	SGR (%/day)	PER
ARASCO	145.42a	1.680c	1.10a	1.75a
Extruded feed with premix (+P)*	134.20a	1.880b	1.09a	1.58b
Extruded feed without premix (-P)**	129.17a	2.090a	0.91a	1.47c
$LSD_{0.05}$	28.325	0.827	0.365	

Figures in columns followed by the same letter are not significantly different by LSD.; (+P)* mean with premix; (-P)** means without premix

Feed Conversion Ratio (FCR): The FCR by the fish ranged from 168-2.09 fed on different diets (Table 4). There was a significant difference in FCR between the control (ARASCO feed) and the extruded feed treatments ($LSD_{.05}$ = 0.827). Highest FCR was obtained with extruded feed without premix as compared to the extruded feed with premix and the commercial feed (ARASCO). This showed that extruded feed can successfully be used in aquaculture as an alternate source of protein in fish diet. It will further minimize the commercial feed import issue for the fish growers.

Specific Growth Rate (SGR): The SGR of Nile tilapia ranged from 0.91-1.10 fed on different diets (Table 4). There was no significant difference in SGR of Nile tilapia among various feeds ($LSD_{.05}$ = 0.365). But there was a decreasing trend in SGR with extruded feed with and without premix than the commercial feed (ARASCO). This suggests that fish can easily be reared on extruded feed for optimal production. The results agree with those of Rodriguez *et al.* (1996) who concluded that animal by-product meal can be used as a sole protein source in commercial feed for Nile tilapia fry without affecting growth and food utilization.

Protein Efficiency Ratio (PER): The PER of Nile tilapia ranged from 1.47-1.75 fed on different feeds (Table 4). There was a significant difference in FER among different fish diets ($LSD_{.05}$ = 0.124). The PER decreased significantly with extruded feed without premix as compared to the control treatment (ARASCO Feed) and the extruded feed with premix. This could be due to more consumption of ARASCO feed by fish than the extruded feed for higher PER. Similarly, Samocha *et al.* (2004) stated that the survival, final weight and FE were not significantly different when co-extruded soybean poultry by-product with egg supplement was substituted for fish feed meal in a practical diet formulated to contain 32% crude protein and 8% lipid.

CONCLUSIONS

Mean fish body weight and SGR were not affected by different types of feed. However, the FCR and the PER

were significantly affected by the different feeds. The FCR was significantly higher in the extruded feed without premix than the commercial feed (ARASCO) and the extruded feed with premix. In contrast, the PER was higher in commercial ARASCO feed than the extruded feed with and without premix. The present study showed that the extruded leftover food could be used to prepare least cost diet for Nile tilapia by the extrusion technique which seems more practical in mitigating the environmental hazards due to the land disposal of leftover food.

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