# LOCAL INGREDIENTS SUBSTITUTING FOR FISHMEAL IN TILAPIA AND PACU DIETS IN GUYANA

Sustainable Feed Technology/Activity/ 07SFT05UA

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## ABSTRACT

Following the findings of the preliminary study examining the potential availability and quality of local ingredients for aquaculture diets, we conducted a series of feeding trials to determine if the locally formulated feeds would be significantly different from the commercially available feed using imported ingredients. Tilapia feeding trials determined that an equal mix (50-50%) of poultry by-product meal and shrimp meal (heads and peels) that are locally available in Guyana could be substituted for the imported fish meal currently used in the locally formulated and manufactured diet currently available to tilapia farmers. The investigation determined this to be the situation with both fingerlings (20g average) and growout (100g average) fish. Tilapia fed a mix of 25-75% or 75-25% poultry and shrimp replacement of fish meal had significantly less growth and a higher Feed Conversion Ratio,

## INTRODUCTION

Objectives:

a. To test experimental diets on Tilapia and Pacu reared in cages and ponds.

b. Trial one will replace 20%, 50% and 80% of fish meal with locally derived poultry by-product meal (Null hypothesis – growth rates and Feed Conversion Ratios will not be significantly different)

c. Trial two will replace 20%, 50% and 80% of fish meal with locally derived shrimp by-product meal (Null hypothesis – growth rates and Feed Conversion Ratios will not be significantly different)

d. Trial three will incorporate both poultry by-product and shrimp meal in a combination suggested by the results of the earlier trial

Aquaculture, for marine and brackish water species as well as for freshwater species, is expanding rapidly throughout the world. Some of the driving force for this expansion is simply the need for additional food resources. However, in other cases the demand is caused by the recognition of fish oils and other products as healthy substitutes for other traditional products. New potential aquatic species are being studied and cultured each year creating a need for specialized formula feeds and feed ingredients.

Fishes have no particular requirement for specific raw materials instead they require essential nutrients such as amino acids, fatty acids, minerals, vitamins and pigments. This means that a variety of raw materials used in combination with others could potentially provide all the necessary nutrients and energy required to support good growth performance.

Farming of fishes requires that the diets supplied are nutritionally complete. Consequently, the choice of which raw materials to include in commercial feeds is critically important if fish are to obtain the correct balance of nutrients to sustain good growth, good health and good flesh quality.

Production of farmed tilapia is among the fastest expanding food sectors in the world. The Nile tilapia is the most cultured freshwater species among the farmed tilapias. However, the sustenance and expansion of production is limited by the high cost of fish feeds, which comprise over 60% of the production costs. Protein usually is the most expensive nutrient and its level and quality determine the cost of fish feeds (Tacon 1993).

Most fish feeds contain a proportion of animal protein, which is considered superior to other sources in terms of palatability and nutrient availability (Tacon 1993; Hardy and Tacon 2002). The majority of fish feeds contain fish meal as the main sources of dietary animal protein. However, due to worldwide decline in fishery products, fish meals are increasingly becoming scarce and expensive. Consequently, nutritionists and feed manufacturers have been searching for alternative dietary animal protein from non-conventional sources to replace the conventional sources and reduce feed costs (El-Sayed 1998; Abdelghany 2003; Liti et al 2005).

Tilapia (*Oreochromis niloticus*) and pacu (*Colossoma macropomum*) aquaculture has been developing in recent years in Guyana. In 2006 the growers organized into a farmer's cooperative, the National Aquaculture Association of Guyana. With the assistance of the Ministry of Agriculture and the USAID/GTIS Programme, the farmers have begun to develop local markets and would like to develop an export trade. The Mon Repos Aquaculture station has worked with the farmers to provide technical assistance and training (Geer 2004, 2006).

Feed costs represent 60-75% of the variable production costs in Guyana. The currently available, locally produced, commercial feed has ingredient costs of approximately $0.36 / kg ($360 /mt) and contains almost 25% fish meal. Fish meal prices are rising and the sustainability of fishmeal harvest is questionable. Use of alternatives ingredients, especially locally available by-product meals would be preferable for economic as well as environmental reasons.

One of our goals is to work collaboratively with the commercial feed mill and the fish farmers to develop economically attractive feeds that contribute to sustainability, which has been identified as a priority for the aquaculture producers. Utilization of local feed ingredients, minimizing the use of fish meal, and increasing the efficiency of the feed that is input to the system are immediate targets.

Reducing costs, using local ingredients, and reducing fish meal usage are all laudable goals, but will be meaningless if the feed quality or efficiency are reduced. Fish effluents leaving a cage or being discharged from a pond will be increased is food is not converted to fish biomass. Our goal is to improve the diets nutritional efficiency, by being more nutrient dense, that is matching the nutritional need with the dietary ingredients (Lim and Webster 2006). Poultry by-product meal has been shown to be an effective protein replacement for up to 50% of fish meal in tilapia diets (Viola and Zohar 1984) and Williams et al. (1998) demonstrated that shrimp meal could also be used as a suitable ingredient to replace fishmeal.

## METHODS AND RESULTS:

Objectives:

a. To test experimental diets on Tilapia reared in cages and ponds.

Due to several flooding events, the feeding trials were eventually completed in tanks. The tanks were arrayed with three replicates of each experimental diet and the tanks were fitted with separate recirculation systems. Stocks of pacu were not available during the experimental period. Cage and ponds trials are still planned and should be completed in the future but after the required deadline for submission of this report. Trials with pacu are also expected to be completed in the future, but again after the submission of this report.

b. Trial one replaced 20%, 50% and 80% of fish meal with locally derived poultry by-product meal (Null hypothesis – growth rates and Feed Conversion Ratios were not be significantly different)

This experimental diet was developed for tilapia fingerlings. The experiment was conducted in twelve 1m³ tanks. Each tank had 15 fingerlings with average weights between 16-23 grams per tank. There were 30 fingerlings in one 2m³ tank for the control. All the tanks had 1 liter of media 1/3 crushed snail shell and 2/3 gravel. The water in the tanks was exchanged using a slow drip system.

The results demonstrated that there were no significant differences in growth rates between the diets nor were FCR's significantly different between the control or the experimental diets.

c. Trial two replaced 20%, 50% and 80% of fish meal with locally derived shrimp by-product meal (Null hypothesis – growth rates and Feed Conversion Ratios were not be significantly different)

This experimental diet was developed for early growout stage tilapia. The experiment was conducted in twelve 1m³ tanks. Each tank had 10 mature fish with average weights between 62-126 grams per tank. There were 20 mature fish in one 2m³ tank for the control. All the tanks had 1 liter of media 1/3 crushed snail shell and 2/3 gravel. The water in the tanks was exchanged using a slow drip system.

The results demonstrated that there were no significant differences in growth rates between the diets nor were FCR's significantly different between the control or the experimental diets.

d. Trial three incorporated both poultry by-product and shrimp meal in a combination suggested by the results of the earlier trials

The study was conducted at the Satyadeow Sawh Aquaculture Station, Mon Repos, East Coast Demerara, Guyana from 28th July – 21st Sept 2009. As no pacu were available for this feed trial, it was repeated for fingerlings and growout size fish. The diet formulations are described below in table format.

**Fingerlings trial - Tank Preparation**
The experiment was conducted in twelve 1m³ tanks. Each tank had 15 fingerlings with average weights between 16-23 grams per tank. There were 30 fingerlings in one 2m³ tank for the control. All the tanks had 1 liter of media 1/3 crushed snail shell and 2/3 gravel. The water in the tanks was exchanged using a slow drip system.

**Treatments** The study had three treatments i) 25% shrimp meal and 75 % poultry meal, ii) 50% shrimp meal and 50 % poultry meal, iii) 75% shrimp meal and 25 % poultry meal. There was one control with 50% fish meal.

**Grow-out trial - Tank Preparation for growout**
The experiment was conducted in twelve 1m³ tanks. Each tank had 10 mature fish with average weights between 62-126 grams per tank. There were 20 mature fish in one 2m³ tank for the control. All the tanks had 1 liter of media 1/3 crushed snail shell and 2/3 gravel. The water in the tanks was exchanged using a slow drip system.

**Treatments** The study had three treatments i) 25% shrimp meal and 75% poultry meal, ii) 50% shrimp meal and 50% poultry meal, iii) 75% shrimp meal and 25 % poultry meal. There was one control with 27.7% fish meal

The diets were randomly allocated to groups of all male *Oreochromis spp.* fingerlings and mature fishes. They were fed all the three diets in four treatments for the fingerling trial and the same was done for the grow-out trials.

Fish were acclimatized for one week prior to the start of each experiment. The feed was sifted and the fish were fed manually, three times per day for the fingerling trial and two times per day for the grow-out trial. They were fed 5% and 3% of body weight per day for the fingerling and grow-out trials. All the fishes in the fingerling and grow-out tanks were weighed and measured on a weekly basis in the inception of the experiment to monitor growth and adjust feeding rates. However, it was conducted fortnightly from the fifth week of the experiment.

Final weights were determined at the end of nine weeks by weighing and measuring each fish. Data was analyzed with Single Factor ANOVA.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **F/ling Fish Feed** | | | | | **Protein** | | |
| **% Incl** | **Ingredient** | **Amount** | **Cost** | **Total** | **Protein** | **Content** | | **shrimp/pou** |
| | **Regular** | **g** | **$** | **$** | **%** | **%** | | |
| 0 | Soy Meal | 0 | 0 | 0 | 44 | 0 | | |
| 50 | Fish meal | 10227 | 0 | 1,636 | 61.49 | 31 | | |
| 0 | Shrmp meal | 0 | 0 | 0 | 39.1 | 0 | | |
| 0 | Pltry Meal | 0 | 0 | 0 | 48 | 0 | | |
| 11.2 | Rice bran | 2290 | 0 | 50 | 12.9 | 1 | | |
| 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 | | |
| 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 | | |
| 100 | | 20452 | | **$2,056** | | **39** | | |
| | **Sample #1** | | | | | | | |
| 0 | Soy Meal | 0 | 0 | 0 | 44 | 0 | | |
| 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 | | 25/75 |
| 12.5 | Shrmp meal | 2556 | 0 | 256 | 39.1 | 5 | | |
| 37.5 | Pltry Meal | 7670 | 0 | 862 | 48 | 18 | | |
| 11.2 | Rice bran | 2290 | 0 | 50 | 12.9 | 1 | | |
| 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 | | |
| 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 | | |
| 100 | | 20451 | | **$1,537** | | **31** | | |
| | | | | | | | | |
| | **Sample #2** | | | | | | | |
| 0 | Soy Meal | 0 | 0 | 0 | 44 | 0 | | |
| 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 | | 50/50 |
| 25 | Shrmp meal | 5113 | 0 | 511 | 39.1 | 10 | | |
| 25 | Pltry Meal | 5113 | 0 | 575 | 48 | 12 | | |
| 11.1 | Rice bran | 2290 | 0 | 50 | 12.9 | 1 | | |
| 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 | | |
| 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 | | |
| 99.9 | | 20451 | | **$1,506** | | **30** | | |
| | | | | | | | | |
| | **Sample #3** | | | | | | | |
| 0 | Soy Meal | 0 | 0 | 0 | 44 | 0 | | 75/25 |
| 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 | | |
| 37.5 | Shrmp meal | 7670 | 0 | 767 | 39.1 | 15 | | |
| 12.5 | Pltry Meal | 2556 | 0 | 287 | 48 | 6 | | |
| 11.1 | Rice bran | 2290 | 0 | 50 | 12.9 | 1 | | |
| 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 | | |
| 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 | | |
| 99.9 | | 20451 | | **$1,474** | | **29** | | |

| | | | | Growout Fish Feed | | | | | Protein |
|---|---|---|---|---|---|---|---|---|---|
| | | | % Incl | Ingredient | Amount | Cost | Total | Protein | Content |
| | | | | Regular | g | $ | $ | % | % |
| | | | 27.7 | Fish meal | 5665 | 0 | 906 | 61.49 | 17 |
| | | | 22.2 | Soy Meal | 4540 | 0 | 520 | 44 | 10 |
| | | | 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 |
| | | | 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 |
| | | | 11.2 | Rice bran | 2270 | 0 | 50 | 12.9 | 1 |
| | | | 0 | Shrmp meal | 0 | 0 | 0 | 39.1 | 0 |
| | | | 0 | Pltry Meal | 0 | 0 | 0 | 48 | 0 |
| | | | 99.9 | | 20410 | | **$1,846** | | **35** |
| | | | | Sample #1 | | | | | |
| | 25/75 | | 22.2 | Soy Meal | 4540 | 0 | 520 | 44 | 10 |
| | | | 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 |
| Tanks 17,18,19,20 | | | 6.95 | Shrmp meal | 1421 | 0 | 142 | 39.1 | 3 |
| | | | 20.75 | Pltry Meal | 4244 | 0 | 477 | 48 | 10 |
| | | | 11.2 | Rice bran | 2270 | 0 | 50 | 12.9 | 1 |
| | | | 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 |
| | | | 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 |
| | | | 99.9 | | 20410 | | **$1,559** | | **30** |
| | | | | | | | | | |
| | | | | Sample #2 | | | | | |
| | 50/50 | | 22.2 | Soy Meal | 4540 | 0 | 520 | 44 | 10 |
| | | | 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 |
| | | | 13.85 | Shrmp meal | 2832 | 0 | 283 | 39.1 | 5 |
| Tanks 21,22,23, 24 | | | 13.85 | Pltry Meal | 2832 | 0 | 318 | 48 | 7 |
| | | | 11.2 | Rice bran | 2270 | 0 | 50 | 12.9 | 1 |
| | | | 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 |
| | | | 22.2 | Cocofat | 4540 | 0 | 160 | 23 | 5 |
| | | | 99.9 | | 20409 | | **$1,541** | | **30** |
| | | | | | | | | | |
| | | | | Sample #3 | | | | | |
| | 75/25 | | 22.2 | Soy Meal | 4540 | 0 | 520 | 44 | 10 |
| | | | 0 | Fish meal | 0 | 0 | 0 | 61.49 | 0 |
| | | | 20.75 | Shrmp meal | 4244 | 0 | 424 | 39.1 | 8 |
| | | | 6.95 | Pltry Meal | 1421 | 0 | 160 | 48 | 3 |
| | | | 11.2 | Rice bran | 2270 | 0 | 50 | 12.9 | 1 |
| Tanks 13,14,15,16 | | | 16.6 | Broken | 3395 | 0 | 209 | 8.7 | 1 |
| | | | 22.3 | Cocofat | 4540 | 0 | 160 | 23 | 5 |
| | | | 100 | | 20410 | | **$1,524** | | **29** |

Note that the fingerling diets without fishmeal are about $500 per ton less expensive while the growout diets with fishmeal are about $300 per ton less expensive. The experimental diets also are reduced in protein level as the shrimp and poultry are both lower in protein 39% and 48% respectively. Further we should note the high cost of the diets compared to typical world prices for similar diets which would be less than half the price in Guyana.

Both trials had a high level of survival. The few mortalities were directly related to interruptions in water flow to the affected tanks.

Figure 1. Growth of fingerlings fed experimental and control diets.

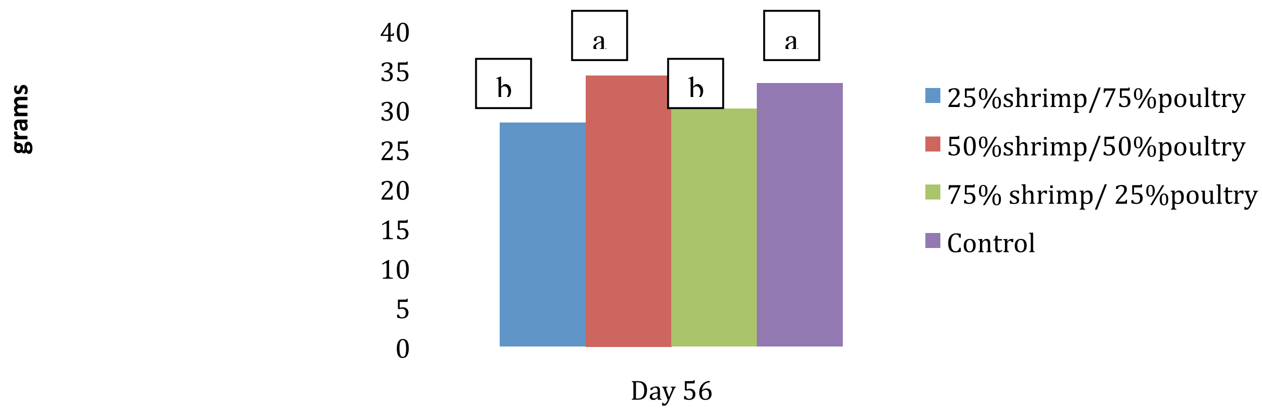
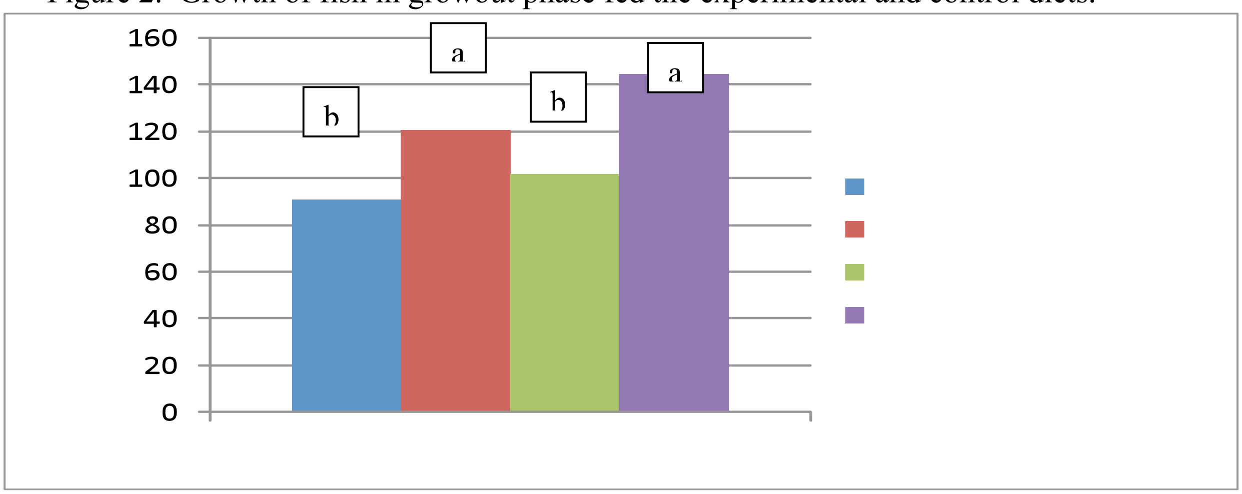



Figure 2. Growth of fish in growout phase fed the experimental and control diets.




## CONCLUSIONS

The fingerling diet with a 50/50 mix of poultry and shrimp meal replacing fish meal in the diets was found to be similar to the control diet with no significant difference, while the 25/75 and 75/25 diets were found to provide significantly less growth for the tilapia fingerlings after nine weeks (one week acclimation and eight week trial). The Feed Conversion Ratios demonstrated the same pattern with control and 50-50% mix diets having FCR's that were not different and the 25-75 and 75-25% mixes having FCRs that were significantly higher, but not different from each other.

The larger growout size fish fed a 50/50 % mix of poultry and shrimp meal were also found to add weight at an equivalent rate to the control diet with fish meal. The diets with 25/75% and 75/25% mixes of poultry and shrimp were found to be significantly less than the control and not significantly different from each other. The Feed Conversion Ratios demonstrated the same pattern with control and 50-50% mix diets having FCR's that were not different and the 25-75 and 75-25% mixes having FCRs that were significantly higher, but not different from each other.

We theorize that the 50-50% mix of poultry and shrimp meal may have an amino acid profile that better approximates that of the fish meal than either of the 25-75 or 75-25% mixtures.

## ECONOMIC ANALYSIS

As the fingerling diet with the 50-50% mix was approximately $500 per ton less expensive and the growout diet was $300 less, the experimental diets would appear to be very cost effective and should be able to provide a significant savings for farmers.

## LITERATURE CITED

Geer, T. 2004. Report on the activities of the Mon Repos Freshwater Aquaculture Demonstration Farm and Training Centre - July 2001 to December 2003. Guyana Ministry of Agriculture, Department of Fisheries.

Geer, T. 2006. Report on the activities of the Mon Repos Freshwater Aquaculture Demonstration Farm and Training Centre - January to December 2005. Guyana Ministry of Agriculture, Department of Fisheries.

Lim, C. and Webster, C. 2006. Nutrient requirements. In: Tilapia: Biology, Culture, and Nutrition. Eds. Lim. C. and Webster, C. Haworth Press.

Viola, S. and Zohar, G. 1984. Nutritional study with market size tilapia hybrid *Oreochromis* in intensive culture: Protein levels and sources. Israeli Journal of Aquaculture (Bamidgeh) 35:9-17.

Williams, K.C., Allan, G.L., Smith, D.M., Barlow, C.G., 1998. Fish meal replacement in aquaculture diets using rendered protein meals. In: Banks, G. Ed., Proceedings of the 4th International Symposium in Animal Nutrition. Australian Renderers Association. Baulkham Hills, NSW, Australia. Fisheries Research and Development, 14 pp.