DEVELOPMENT OF LOW-COST SUPPLEMENTAL FEEDS FOR TILAPIA IN POND AND CAGE CULTURE

Eighth Work Plan, Philippines Research 1 (PHR1)
Progress Report

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ABSTRACT

Two feeding trials were conducted at the Central Luzon State University Freshwater Aquaculture Center in the Philippines to determine the viability of using yeast and composted rice straw as alternative protein sources for tilapia diets. In the first phase, the experimental diets were prepared using a meat grinder to make pellets and fed to tilapia in ponds. In the second phase, the diets were fed to tilapia in cages in a common pond. In both experiments, the fish fed the diet incorporating the composted straw demonstrated the highest growth rate. In the pond study, 1.5-g tilapia were stocked in fertilized ponds, allowed to grow for seven months, and then fed the experimental feed for three months. The fish grew to an average of 141.3, 134.6, and 106 g in the compost, yeast, and un-fed control ponds, respectively. The ponds also yielded fingerlings with an average biomass of 124.3, 101.0, and 57.2 kg per pond in the compost, yeast, and un-fed controls, respectively. In the second phase, the fish were stocked into hapa cages at an average size of 73.9 g. In three months the fish grew to average sizes of 162.6, 155.6, 148.8, and 146.6 g when fed the compost diet prepared on a meat grinder, compost diet from a pellet mill, yeast diet from a grinder, and yeast diet from a pellet mill, respectively. Based on the results of these trials we conclude that these low-cost supplemental feeds would increase the yield from ponds and the composted rice straw would be the better protein source for the replacement of fishmeal compared to the variety of yeast used in the diet.

INTRODUCTION

Supplemental feeds providing additional quantities of nutrients are needed when the productivity of a water body cannot provide for the fish growth desired. Low-cost, high-quality feeds are needed in ponds when farmers wish to produce more fish than can be supported from fertilized systems (Diana et al., 1994) and in instances where cages are stocked with fish which do not have access to the entire water body for feeding. Many small-scale farmers have been encouraged to build and utilize cages to increase their household income and nutrition. After construction of the cage, cost of feed becomes the major input cost for fish production. Commercial feeds are widely used in the Philippines, mostly for cage farms which require a fairly complete diet. These diets contain a relatively complete set of nutrients, which may not be necessary for pond-reared fish.

Supplemental feeds, by definition, are not intended to provide complete nutrition. The goal is to provide nutrients that otherwise would be limiting the growth of the fish. In fertilized ponds, proteins are often that limiting factor. Providing protein in feeds can be cost-effective by increasing the growth rate of fish stocked in a pond and allowing more fish to be stocked in the same water volume. But dietary protein is often expensive to incorporate into a diet. The typical sources of proteins are fishmeal and soybean oil meal. These are relatively expensive ingredients that are useful in other animal feeds. With the recent financial problems in Asia and the devaluation of local currencies, fishmeal costs have risen to new highs. Providing less expensive sources of protein has been a goal of numerous other nutrition studies in the past, which have examined many ingredients including plants, agricultural processing wastes, and even brewery wastes. One source of protein that historically was prohibitively expensive is yeast. Brewer's and baker's yeast are known to be high in protein and readily digestible. New bioreactor technology has lowered the cost of yeast to the point that it now may be cost-effective to use as an ingredient. One common yeast used in feed studies that is commercially available in many areas is *Saccharomyces cereviseae*.

Rice bran is one of the agricultural by-products that have been used in supplemental diets in the past. Another material available from rice production is rice straw. However, the straw is not high in protein. One option is to compost the straw, which will allow microbial activity to use the straw as substrate and convert the straw from a material high in indigestible matter, with a high carbon-to-nitrogen ratio, to microbial biomass that is quite digestible for tilapia, with a low carbon-to-nitrogen ratio. In an effort to find a lower-cost ingredient as a fishmeal replacement we developed experimental diets that incorporated yeast and composted rice straw as replacements for fishmeal in a simple diet

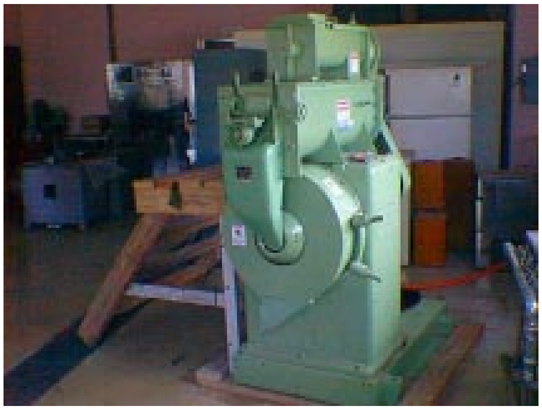

Figure 1. Compression pellet mill used to make experimental tilapia diets.

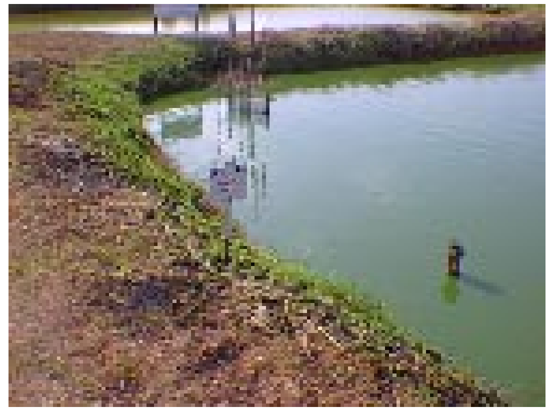

Figure 2. Experimental pond receiving diet containing yeast.

formulation. Another aspect of the study was to determine if compression pelleting would make a difference in the performance of the diet. The experimental feeds developed at the Freshwater Aquaculture Center (FAC) in the past had been manufactured on a simple meat grinder. The strands were hand-dried and broken into small, pellet-size particles that could be consumed by the fish. A pellet mill was purchased in the US and delivered to the FAC (Figure 1). The mill was used to make compressed pellets using the same ingredient mix prepared on the meat grinder. The two forms were then tested in cages in a common pond.

A supporting study was conducted by an Arizona high school student. The student conducted the experiment as part of a science fair project. In this study the student used a composted rice diet prepared at the University of Arizona according to the formula used in the Philippines. This diet was compared to a commercially available tilapia diet used in the US.

Methods and Materials

Phase 1

Twelve earthen ponds at the Freshwater Aquaculture Center at Central Luzon State University were used to test the experimental diets. The ponds were 0.05 ha each with a depth of one meter (Figure 2). Monosex (genetically male) *Oreochromis niloticus* from the Genetically Male Tilapia (GMT) program were stocked on 10 June 1997 at 3 fingerlings m^{-2} or 1,500 fish $pond^{-1}$.

Each of the 12 ponds was fertilized with nutrient inputs from urea (46-0-0) and ammonium phosphate (16-20-0) at the rate of 14 kg N and 2.8 kg P ha^{-1} wk^{-1}. To attain the desired input levels, 1.625 kg of 16-20-0 and 1.1 kg of urea (45-0-0) were added each week to each 500-m^2 pond. This assumes a moisture content of approximately 5% in the fertilizer. Dissolved fertilizer was broadcast across the entire pond surface. The application of nutrients was stopped once feeding of the experimental diets was begun, and continued in ponds that received fertilizers only (the control ponds). Feeding with the experimental diets started in February of 1998 at 5% of body weight for 2 months and 3% of body weight per day during April with harvest in early May of 1998. Four ponds were fed the yeast diet, four were fed the composted rice straw diet, and four ponds were un-fed, fertilized control ponds.

The yeast diet was composed of 60% rice bran, 15% yeast, and 25% meat and bone meal. Commercially available yeast was used to prepare the yeast diet. The rice diet was 60% rice bran, 15% rice straw, and 25% meat and bone meal. Two batches of rice straw were composted, one in January of 1997 and the other in June of 1997. These two batches were mixed together to provide the compost ingredient for the experimental diet. The rice compost preparation did not

Figure 3. Harvesting tilapia from pond receiving yeast diet.

Figure 4. Hapas used in feeding trial.

Table 1. Water parameters were analyzed (APHA, 1980; Boyd, 1979) at initial stocking and every two weeks thereafter at FAC, Philippines (Phase 2).

Parameter	Depth	Time	Analytical Methods
Temperature	Top, mid, bottom	AM & PM	YSI meter & probe
Dissolved O_2	Top, mid, bottom	AM & PM	YSI meter & probe
Alkalinity	Column sample	AM	Titration
pH	Top, mid, bottom	AM & PM	pH meter
Total NH_3-N	Column sample	AM	Indophenol method
Secchi Disk	Column sample	AM & PM	Visual
Sol. React. Phos.	Column sample	AM	Molybdate method

Table 2. Survival and average weight of *O. niloticus* reared in ponds fed compost and yeast diets. Values with similar letters are not significantly different; values with different letters are significantly different ($P = 0.05$).

Treatment	Average Mortality (%)	Final Average Weight ± s.d. (g)	Ave. Biomass of Fingerlings ± s.d. (kg)
Compost Diet	20.8 (a)	141.3 ± 5.3 (c)	124.3 ± 62.1 (e)
Yeast Diet	9.2 (a)	134.6 ± 2.9 (c)	101.0 ± 81.3 (e)
Control Ponds	44.8 (b)	106.1 ± 1.8 (d)	57.2 ± 43.5 (e)

involve any nutrient supplements nor any manure. The ingredients for the experimental diets were mixed as dry ingredients and then prepared on a meat grinder.

Sample weights were determined monthly. Fifty fish were sampled per pond by collection with a seine net (Figure 3). Feeding amount was adjusted according to the average weight of the fish sampled. At harvest, weights were determined for all of the large fish in each pond. The fingerlings were weighed in bulk, with no determination of number.

Phase 2

The second feeding trial was designed as a 2x2 factorial experiment (feed preparation by pellet mill or meat grinder, and compost or yeast diets). The same diet formulations were used as in Phase 1. Twenty cages, each 6 m^3, were placed into a 0.25-ha pond with a depth of 1.5 to 2 m (Figure 4). The cages were stocked with 120 *O. niloticus* fingerlings from the Genetically Improved Farmed Tilapia (GIFT) program which had already been sex-reversed using methyltestosterone feed per standard FAC protocols. The fish averaged 73.9 g each and were stocked 29 January 1998.

A compression style pelleting mill (CPM Master Series) was purchased and sent to the Philippines as a part of the project. The mill was used to pelletize a portion of the dry mix at the same time that the mix was prepared on the meat grinder. This provided equal portions of the compost and yeast diet feeds to be tested in their various forms.

The ponds receiving the rice compost and the yeast diets and the pond containing the hapa net feeding trial were monitored daily for water level. A comprehensive analysis of water quality was performed every two weeks including temperature, pH, alkalinity, dissolved oxygen, total available nitrogen, phosphate, and Secchi disk visibility (Table 1).

For Phases 1 and 2, the results were compared using one-way analysis of variance to determine differences and Duncan's Multiple Means test to determine differences between several treatments.

Chino Valley High School Study

The study was conducted at Chino Valley High in Chino, Arizona. Non-sex-reversed *O. niloticus* and hybrid red tilapia were used as the experimental animals. The fish were fed a composted rice diet (60% rice bran, 15% rice straw, and 25% meat and bone meal) prepared on a compression pellet mill (CPM) and a commercially available tilapia diet (Ace High Brand). Four perforated plastic buckets (20 l) were placed into a 1000-liter tank; two replicates of 21 fish each were used for each diet. The fish were fed twice daily at a feeding rate of 5% of the biomass. The trial lasted six weeks.

RESULTS

Phase 1

The twelve ponds were harvested in early May of 1998. Even though the fish were expected to be all males from the GMT program, only one pond did not have any reproduction. Most of the adult fish harvested appeared to be male. It appears that either there was contamination with females at some point or,

Figure 5. Fingerlings recovered from pond stocked with genetically male tilapia (GMT).

Table 3. Water quality sampling results in cage trials (hapas), FAC, Philippines (Phase 2).

Sampling Position	Date (MMDDYY)	Dissolved O_2 (mg l^{-1})						Temperature (°C)					
		Top AM	*Mid AM*	*Bottom AM*	*Top PM*	*Mid PM*	*Bottom PM*	*Top AM*	*Mid AM*	*Bottom AM*	*Top PM*	*Mid PM*	*Bottom PM*
7C.1	12998	1.4	1.3	1.2	4.0	4.0	4.0	25.2	25.2	25.2	29.3	29.3	29.3
7C.2	12998	1.4	1.3	1.2	3.9	3.9	3.9	25.1	25.1	25.1	29.0	29.0	28.8
7C.3	12998	1.4	1.2	1.2	3.9	3.9	3.9	25.2	25.2	25.2	29.1	29.1	29.1
7C.4	12998	1.3	1.3	1.1	4.0	4.0	4.0	25.2	25.2	25.2	29.0	29.0	29.0
7C.5	12998	1.4	1.3	1.2	4.0	4.0	4.0	25.2	25.2	25.2	29.0	29.0	29.0
7C.1	21398	2.9	2.8	2.7	5.4	5.4	5.5	27.5	27.5	27.5	32.0	31.9	31.6
7C.2	21398	2.9	2.7	2.7	5.4	5.6	5.6	27.5	27.5	27.5	31.8	31.6	31.5
7C.3	21398	2.8	2.8	2.6	5.6	5.6	5.5	27.5	27.5	27.5	31.8	31.6	31.5
7C.4	21398	2.9	2.7	2.7	5.5	5.5	5.6	27.5	27.5	27.5	32.0	31.9	31.7
7C.5	21398	2.7	2.6	2.5	5.5	5.4	5.4	27.5	27.5	27.5	31.9	31.8	31.6
7C.1	22698	2.3	2.2	2.0	10.2	9.2	8.8	25.8	25.8	25.8	32.8	31.8	31.3
7C.2	22698	2.1	2.0	1.9	10.1	9.0	8.9	25.8	25.8	25.8	32.8	32.0	31.3
7C.3	22698	2.3	2.1	2.0	10.2	9.1	8.8	25.9	25.9	25.9	32.9	31.9	31.3
7C.4	22698	2.3	2.1	2.0	10.2	9.1	8.9	25.8	25.8	25.8	32.8	31.9	31.2
7C.5	22698	2.4	2.3	2.1	10.2	9.2	8.8	25.9	25.9	25.9	32.8	31.8	31.2
7C.1	31298	2.4	2.3	2.2	10.4	9.4	5.9	28.5	28.5	28.5	32.1	31.6	31.0
7C.2	31298	2.4	2.3	2.2	10.8	9.5	6.2	28.5	28.5	28.5	32.5	31.5	31.2
7C.3	31298	2.3	2.3	2.2	10.5	9.5	6.2	28.4	28.4	28.4	32.4	31.5	31.2
7C.4	31298	2.4	2.3	2.2	10.6	9.5	6.3	28.5	28.5	28.5	32.2	31.4	31.0
7C.5	31298	2.3	2.3	2.2	10.4	9.5	6.0	28.5	28.5	28.5	32.2	31.5	31.0
7C.1	32698	1.8	1.8	1.6	12.4	12.3	12.3	26.0	26.0	26.0	29.1	29.1	29.1
7C.2	32698	1.9	1.8	1.6	12.4	12.4	12.3	26.1	26.1	26.1	29.2	29.2	29.2
7C.3	32698	2.0	1.9	1.7	12.4	12.3	12.3	26.0	26.0	26.0	29.1	29.1	29.1
7C.4	32698	1.8	1.8	1.6	12.4	12.4	12.3	26.0	26.0	26.0	29.1	29.1	29.1
7C.5	32698	1.8	1.8	1.6	12.4	12.3	12.3	26.1	26.1	26.1	29.1	29.1	29.1
7C.1	41698	2.1	2.0	1.5	13.2	13.2	13.1	26.8	26.8	26.8	31.5	31.2	31.2
7C.2	41698	2.1	2.0	1.6	13.2	13.1	13.0	26.8	26.8	26.8	31.3	31.2	31.1
7C.3	41698	1.9	1.8	1.5	13.1	13.2	13.0	26.8	26.8	26.8	31.5	31.2	30.9
7C.4	41698	2.0	1.9	1.6	13.2	13.2	12.9	26.7	26.7	26.7	31.5	30.9	30.7
7C.5	41698	2.0	1.8	1.6	13.2	13.1	12.9	26.7	26.7	26.7	31.3	31.0	30.8
7C.1	50498	2.3	2.2	1.6	20	20	16.6	27.3	27.3	27.3	33.2	33.2	33.2
7C.2	50498	2.3	2.1	1.5	19	19	17.1	26.9	26.9	26.9	33.1	33.0	33.0
7C.3	50498	2.2	2.1	1.6	20	19	17.0	27.0	27.0	27.0	33.0	32.0	31.8
7C.4	50498	2.1	2.0	1.6	20	20	16.5	27.3	27.3	27.3	33.0	31.0	31.0
7C.5	50498	2.3	2.1	1.6	20	20	15.8	27.1	27.1	27.1	33.0	32.0	31.8

Table 3. Continued.

Sampling Position	Date (MMDDYY)	pH						Secchi Disk Depth (cm)		Alkalinity (mg l^{-1} $CaCO_3$)	Total Ammonia Nitrogen (mg l^{-1} $CaCO_3$)	Phosphate (mg l^{-1} $CaCO_3$)
		Top AM	*Mid AM*	*Bottom AM*	*Top PM*	*Mid PM*	*Bottom PM*	*AM*	*PM*			
7C.1	12998	8.8	8.8	8.8	9.4	9.3	9.3	46.5	47.5	300	0.041	0.305
7C.2	12998	8.9	8.9	8.9	9.2	9.3	9.3	46.5	47.5	273	0.052	0.340
7C.3	12998	8.9	8.8	8.8	9.2	9.2	9.2	46.5	47.5	314	0.048	0.325
7C.4	12998	8.9	8.9	8.8	9.3	9.3	9.3	46.5	47.5	302	0.030	0.325
7C.5	12998	8.9	8.9	8.9	9.2	9.2	9.2	46.5	47.5	313	0.046	0.340
7C.1	21398	8.9	8.9	8.9	9.5	9.5	9.5	31.5	28.5	295	0.046	0.295
7C.2	21398	8.9	8.9	8.9	9.5	9.4	9.4	31.5	28.5	280	0.054	0.325
7C.3	21398	8.9	8.9	8.9	9.5	9.5	9.4	31.5	28.5	300	0.041	0.325
7C.4	21398	8.9	8.9	8.9	9.4	9.4	9.4	31.5	28.5	296	0.065	0.275
7C.5	21398	8.9	8.9	8.9	9.5	9.4	9.4	31.5	28.5	310	0.047	0.295
7C.1	22698	8.8	8.7	8.7	9.4	9.4	9.3	29.5	29.5	315	0.061	0.390
7C.2	22698	8.8	8.8	8.7	9.5	9.5	9.4	29.5	29.5	295	0.048	0.375
7C.3	22698	8.7	8.7	8.7	9.5	9.4	9.3	29.5	29.5	290	0.046	0.390
7C.4	22698	8.7	8.6	8.7	9.5	9.4	9.4	29.5	29.5	284	0.076	0.390
7C.5	22698	8.7	8.7	8.7	9.5	9.4	9.4	29.5	29.5	268	0.080	0.410
7C.1	31298	8.6	8.6	8.6	9.1	9.0	9.0	47.5	41.5	365	0.011	0.370
7C.2	31298	8.6	8.6	8.6	9.1	9.0	9.0	47.5	41.5	360	0.004	0.285
7C.3	31298	8.6	8.6	8.6	9.0	9.0	8.9	47.5	41.5	363	0.026	0.335
7C.4	31298	8.6	8.6	8.6	9.0	9.0	9.0	47.5	41.5	355	0.024	0.350
7C.5	31298	8.7	8.6	8.6	9.1	9.1	9.1	47.5	41.5	365	0.007	0.300
7C.1	32698	8.7	8.7	8.7	9.4	9.4	9.4	48.5	44.5	342	0.065	0.420
7C.2	32698	8.7	8.8	8.8	9.3	9.3	9.3	48.5	44.5	352	0.046	0.375
7C.3	32698	8.8	8.8	8.8	9.4	9.4	9.4	48.5	44.5	336	0.026	0.285
7C.4	32698	8.7	8.7	8.7	9.4	9.3	9.3	48.5	44.5	341	0.009	0.356
7C.5	32698	8.7	8.7	8.7	9.4	9.4	9.4	48.5	44.5	346	0.041	0.350
7C.1	41698	8.8	8.8	8.8	9.6	9.5	9.5	45.5	42.5	298	0.026	0.365
7C.2	41698	8.8	8.8	8.8	9.6	9.4	9.3	45.5	42.5	324	0.009	0.385
7C.3	41698	8.7	8.7	8.7	9.4	9.3	9.3	45.5	42.5	326	0.036	0.285
7C.4	41698	8.7	8.7	8.7	9.5	9.4	9.2	45.5	42.5	336	0.012	0.346
7C.5	41698	8.8	8.8	8.8	9.6	9.5	9.3	45.5	42.5	310	0.038	0.300
7C.1	50498	8.5	8.5	8.4	10.3	10.3	10.2	38.5	33.5	288	0.075	0.385
7C.2	50498	8.6	8.6	8.5	10.3	10.2	10.2	38.5	33.5	320	0.034	0.378
7C.3	50498	8.5	8.5	8.5	10.2	10.2	10.0	38.5	33.5	315	0.028	0.292
7C.4	50498	8.5	8.5	8.4	10.2	10.1	10.1	38.5	33.5	324	0.015	0.345
7C.5	50498	8.5	8.5	8.5	10.3	10.2	10.1	38.5	33.5	316	0.030	0.316

Table 4. Survival, average weight, and feed conversion ratio of *O. niloticus* reared in cages fed compost and yeast diets prepared on meat grinder and a compression pellet mill at FAC (Phase 2). Values with similar letters are not significantly different; values with different letters are significantly different ($P = 0.05$).

Treatment	Average Mortality (%)	Final Average Weight ± s.d. (g)	Feed Conversion Ratio ± s.d.
COMPOST DIET			
Grinder	4.0 (a)	162.6 ± 4.6 (b)	3.3 ± 0.7 (d)
Pellet Mill	1.3 (a)	155.6 ± 9.7 (b)	2.8 ± 0.1 (d)
YEAST DIET			
Grinder	0.5 (a)	148.8 ± 4.6 (c)	2.6 ± 0.3 (d)
Pellet Mill	1.8 (a)	146.6 ± 8.8 (c)	3.1 ± 0.3 (d)

Table 5. Final average weight and feed conversion ratio of *O. niloticus* and hybrid red tilapia reared in tanks fed rice compost and commercial diets at Chino Valley High School, Arizona. Values with similar letters are not significantly different; values with different letters are significantly different ($P = 0.05$).

Treatment	Final Average *O. niloticus* Weight ± s.d. (g)	Final Average Red Tilapia Weight ± s.d. (g)	Feed Conversion Ratio ± s.d.
Commercial Diet	14.3 ± 5.7 (a)	16.4 ± 6.2 (b)	3.1 ± 2.7 (c)
Compost Diet, Pellet Mill	11.6 ± 5.9 (a)	14.8 ± 3.7 (b)	5.0 ± 3.1 (c)

more likely, the process was not 100% complete in providing all-male fish.

The large fish from each pond were each weighed and counted. These fish were presumed to be the survivors from the original stocking. The biomass of fingerlings was determined by weighing all of the fish that were in the obviously smaller cohort (Figure 5). The fingerlings were not counted. The results are presented in Table 2.

The average mortalities in the ponds fed the two experimental diets were not significantly different from one another, but were significantly greater than the average in the control ponds. The average weights of the fish fed the two experimental diets were also not significantly different from one another but were significantly greater than the fish in the control ponds. Feed Conversion Ratios (FCRs) for compost and yeast diets (1.2 and 1.2) were not significantly different. The biomass of fingerlings for all three treatments were not significantly different. Considering that these fish were supposed to be all-male populations, the number of fingerlings in the ponds was disappointing.

Phase 2

The hapa net cages were harvested on 4 May 1998. The fish were in the cages for 95 days. The dissolved oxygen levels varied in the ponds from a low of 1.1 mg l^{-1} at the bottom of the cages on a morning in January to saturated conditions of up to 20 mg l^{-1} in the afternoon in May. Temperatures ranged from a low of 25.1°C on a January morning to a high of 33.2°C on a May afternoon. The pH extremes in the ponds were recorded between the morning and afternoon of the last sampling date in May. The morning low pH was 8.4 and the afternoon high was 10.3 from the same location. This is indicative of a strong algae bloom driving the carbonate cycle to alter the pH. The Secchi disk readings did not demonstrate any obvious trends other than being slightly lower in the afternoon compared to the morning reading for the same day. Alkalinity did not display any obvious pattern and ranged from 268 to 365 mg l^{-1} $CaCO_3$. Total ammonia and phosphates also did not display any obvious patterns and ranged from 0.004 to 0.080 mg l^{-1} and 0.275 to 0.420 mg l^{-1}, respectively. More complete results are presented in Table 3.

The average mortalities in the hapa nets were very low, with some of the cages having 100% survival. There was no reproduction in any of the cages. The average weights of fish fed the two compost diets were significantly greater than the weights of fish fed the two yeast diets. There were no significant differences between either diet prepared on the pellet mill compared to preparation on the meat grinder (Table 4).

Feed conversions were not significantly different between any of the diets or preparation methods. However, none of the FCRs was very good compared to what would be expected with a commercial diet.

Chino Valley High School Study

The fish at the high school were stocked at an average weight of 5.0 g. At the end of the six-week period the fish were weighed individually. There were no mortalities in any of the replicates (Table 5).

The treatments did not exhibit any significant differences in final average weights or FCRs. However, this may have been because of insufficient numbers in the replicates. Considering the trend that was evident, extending the trial or having a larger population would have probably led to significant differences. Nevertheless, the rice diet did demonstrate that the fish would survive and grow when fed the relatively simple, low-cost, rice-based diet.

DISCUSSION

The trials in the Philippines demonstrated that the yeast and the composted rice straw could provide significant nutrition and contribute to the manufacture of simple, low-cost diets for tilapia culture. Additional trials should be conducted to compare these diets with commercially available diets, which most of the cage farmers and many of the pond producers are now using. Growth differences and cost differential could then be compared to determine the best value of feed to biomass produced. The trial conducted at Chino Valley High School in Arizona demonstrated that the rice compost diet did support growth and was close to the production achieved with the commercial diet, at least for the short period tested.

We were not able to determine if the yeast diet provided significantly different growth compared to the compost. Since the compost diet is much more readily available and would be lower in cost, it would be the preferable ingredient for future examination. A further analysis comparing these diets with commercial diets and standard pond fertilization may also be prudent, especially considering the rapid changes in commodity and feed prices in the Philippines and elsewhere in Southeast Asia.

One severe disappointment from the trial was the large amount of reproductive activity in the ponds stocked with genetically male tilapia (GMT) from the GMT program. We can not be sure that the ponds were not accidentally contaminated with females from outside the GMT program. But considering that all but one pond had reproduction, it is doubtful that all of the ponds received fish from outside the population stocked.

We realize that the treatment ponds should have demonstrated better survival and growth compared to the control ponds which received fertilization only; however, the more impor-tant point is that we generated these results with low costs feeds from readily available ingredients. Achieving this marginal increase in yield that will provide more marginal income than the marginal cost of the feed is the essence of economic progress.

A description of the project with results of the research and many photos of the ponds and fish are posted at the following website: <http://ag.arizona.edu/azaqua/philippines/clsu.htm>.

ANTICIPATED BENEFITS

The rapid increase in commodity prices for feed ingredients is a serious concern for aquaculture producers throughout Southeast Asia. In addition to their own consumption and domestic sales there is increased interest in generating high-quality tilapia fillets for export. High quality fillets are most often produced from cage systems and ponds receiving prepared feeds. Developing low-cost feeds that will allow tilapia farmers to produce high-quality fish for domestic and international markets. This is a goal of the Central Luzon State University (CLSU) biologists, but also a topic of request from two e-mails received directly from Filipino fish farmers.

The low-cost feeds we have developed and tested can be manufactured by the CLSU feed mill for sale to local farmers for further on-farm evaluation. This can be done on a cost recovery basis. If the diets prove popular with farmers, one commercial feed company said they would be interested in testing the formulations themselves. If successful, the benefit would be lower input costs and increased revenues for the growers using this type of feed.

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