# Development of Low Cost Supplemental Feeds for Tilapia in Pond and Cage Culture in the Philippines

*Eighth Work Plan, Philippines Research 1 (PHR1)*

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## Introduction

Supplemental feeds providing additional quantities of nutrients are needed when the productivity of a water body cannot provide sufficient nutrients to achieve the desired fish growth. Low cost but good quality feeds are needed when farmers wish to produce more fish than can be supported by fertilized systems (Diana et al., 1996) and in instances when fish are cage cultured and 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.

Supplemental feeds, by definition, are not intended to provide complete nutrition. The goal is to provide nutrients that otherwise would be limiting to fish growth. In fertilized ponds, proteins are often that limiting factor. Dietary protein is often expensive to incorporate in a diet; however, the provision of protein in feeds may be cost-effective if the growth rate of stocked fish is increased and if protein provision in feed allows for increased numbers of fish to be stocked in the same water volume. The typical sources of proteins are fish meal and soy bean oil meal, which are relatively expensive ingredients that are useful in other animal feeds. Determining less expensive sources of protein has been a goal of previous nutrition studies, which have examined many ingredients from plants, agricultural processing wastes, and even brewery wastes. One source of protein that was historically prohibitively expensive is yeast; however, new bioreactor technology has lowered the cost of yeast to the point that it may now be cost-effective to use as an ingredient. Brewers' and bakers' yeasts are known to be high in protein and readily digestible. One common yeast used in feed studies that is commercially available in many areas is *Saccharomyces cereviseae.*

Rice bran is an agricultural by-product that has 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. Composting is a solution that addresses this problem. Microbes convert the straw from a material high in indigestible matter to microbial biomass that is quite digestible for tilapia.

The current study will examine the potential for using yeast and composted rice straw as ingredients in supplemental tilapia feeds. A secondary aspect of this study will assess the use of compression pelleting technology to form these feeds. Compressed pellets are a technological improvement over diets formed from meat grinding equipment, because the pellet has better stability in water. Fish have a better opportunity to ingest and digest pelleted food.

## Methods and Materials

The trials will be conducted in two parts. In Phase 1, fish will be fed the experimental diets as a supplemental feed in conventional ponds with four ponds per treatment. In Phase 2, fish will be

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

| Parameter | Depth | Time | Analytical Methods |
|---|---|---|---|
| Temperature | Top, mid, bottom | AM and PM | YSI meter and probe |
| Dissolved $O_2$ | Top, mid, bottom | AM and PM | YSI meter and probe |
| Alkalinity | Column sample | AM | Titration |
| pH | Top, mid, bottom | AM and PM | pH meter |
| Total $NH_3$-N | Column sample | AM | Indophenol method |
| Soluble Reactive Phosphorus | Column sample | AM | Molybdate method |

stocked in cages placed in the same pond and fed the experimental diets, with four cages per treatment.

**Phase 1**

Ponds at the Freshwater Aquaculture Center (FAC) at Central Luzon State University (CLSU) are being used to test the experimental diets. On 10 June 1997 we stocked 12 earthen ponds with monosex (genetically male) *Oreochromis niloticus*, purchased from the Fish-Gen Project at CLSU, at a density of three fingerlings $m^{-2}$ (1,500 fish $pond^{-1}$). Each pond has an area of 500 $m^2$ (25 m x 20 m) and a depth of approximately 1 m.

Each of the 12 ponds receives 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 $ha^{-1}$ $wk^{-1}$, respectively. To attain these levels, 1.625 kg of 16-20-0 and 1.1 kg of urea ammonium phosphate (45-0-0) were added weekly to each 500 $m^2$ pond. To calculate fertilizer input we assumed a moisture content of approximately 5% in the fertilizer. Dissolved fertilizer was broadcast across the entire pond surface. Nutrient application will be discontinued once feeding begins in all ponds receiving feeds (experimental ponds) and will continue in ponds receiving only fertilizers (control ponds). Feeding with the experimental diets will be at 5% BWD for two months and 3% BWD during the last month until harvest.

Commercially-available yeast will be used to produce one of the experimental diets (60% rice bran, 15% yeast, 25% meat and bone meal) composted rice straw (60% rice bran, 15% rice straw, 25% meat and bone meal) will be used to produce the other experimental diet. Two batches of rice straw compost were prepared—the first in January 1997 and the second in June 1997. Compost preparation did not involve any nutrient supplementation nor manure additions. The diets will be prepared on a meat grinder for the first trial. A compression-style pelleting mill (CPM Master Series) will be used for future trials.

Body weight and length data were collected at the initial stocking of ponds. Fifty samples per pond were taken. Fish body weight will be determined on a monthly basis by bulk weighing at least 100 individuals per pond and at harvest complete (i.e., 100% of all fish) bulk weights and counts will be made. At the initiation of feeding, fish will be sampled every two weeks in ponds receiving feed, so that feed rations may be adjusted.

The ponds have been allocated randomly to the two pelleted feed treatments (yeast and rice straw compost) and a fertilized pond control treatment. The experimental diets are scheduled to begin on 1 September 1997.

**Phase 2**

Twenty units of 6-$m^3$ cages will accommodate a two x two factorial experiment (feed preparation by pellet mill or meat grinder, and compost or yeast-based diets) with five replicates. The pond where the net cages will be installed has an area of 2,500 $m^2$ and a depth of 1.5 to 2 m. The cages will be stocked with GIFT *Oreochromis niloticus*, sex-reversed by treatment of fry with methyltestosterone feed as per standard FAC protocols.

Table 1 summarizes the water quality parameters measured and the equipment used for measurement.

For Phases 1 and 2, the hypothesis that fish growth will be similar between treatments will be tested with ANOVA. The tests will be performed with

Table 2. Initial, 30-, and 60-day post stocking weights (g).

| Treatment | Pond | Day 0 | Day 30 | Day 60 |
|---|---|---|---|---|
| YEAST | | | | |
| | 5E | 0.5 | 21.9 | 48.0 |
| | 5B | 0.5 | 15.9 | 36.0 |
| | 6A | 3.4 | 9.7 | 16.3 |
| | 6E | 3.1 | 35.2 | 86.0 |
| | Average | 1.9 | 18.3 | 46.6 |
| COMPOST | | | | |
| | 6H | 2.0 | 21.1 | 57.0 |
| | 6F | 2.4 | 31.0 | 71.0 |
| | 5C | 0.7 | 17.9 | 33.0 |
| | 5F | 0.8 | 23.3 | 54.0 |
| | Average | 1.5 | 23.3 | 53.75 |
| FERTILIZER ONLY | | | | |
| | 5J | 1.8 | 33.9 | 80.0 |
| | 6D | 2.8 | 35.4 | 83.8 |
| | 4H | 0.6 | 21.2 | 48.6 |
| | 4J | 0.5 | 22.4 | 51.0 |
| | Average | 1.4 | 28.2 | 65.8 |

the assistance of SAS, SYSTAT, or a comparable software package.

Breeding, fry collection, and hormone treatment were carried out from March through April 1997. The hormone-treated fry were nursed during the whole month of May and were stocked in ponds at three fish $m^{-2}$ on June 10.

## Results

As of September 1997 fish growth is solely dependent on the algal productivity of the ponds.

Table 2 summarizes the results of the initial, and 30- and 60-day post stocking weights. Table 3a displays water quality data (dissolved oxygen, temperature, and pH); table 3b displays water quality data (Secchi disk visibility [SDV], alkalinity, total available nitrogen [TAN] and phosphorus [P]).

## Anticipated Benefits

The suitability of two locally-available sources of protein will be determined, in the anticipation that yeast and composted rice straw can be used to provide an additional protein element in supplemental fish feed. This will reduce feed costs compared with currently-used fish meal protein sources. This research will also determine the relative efficiencies of two modes of feed preparation, a meat grinder or a pellet mill.

## Literature Cited

APHA, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D.C., 1134 pp.

Boyd, C., 1979. Water Quality in Warmwater Fish Ponds. Agricultural Experiment Station, Auburn University, Alabama, 359 pp.

Diana, J., C.K. Lin, and Y. Yi, 1996. Timing of supplemental feeding for tilapia production. J. World Aquaculture Soc., 27:410-419.

Table 3a. Results of initial water sampling (average of each parameter).

| Sample # | Treatment | Pond | Dissolved Oxygen (mg $l^{-1}$) | | Temperature (°C) | | pH | |
|---|---|---|---|---|---|---|---|---|
| | | | *AM* | *PM* | *AM* | *PM* | *AM* | *PM* |
| #0 | | | | | | | | |
| | *Yeast* | 5E | 1.83 | 10.37 | 30 | 33.9 | 7.2 | 7.8 |
| | | 5B | 4.53 | 11.5 | 30 | 35.2 | 7.6 | 8.1 |
| | | 6A | 4.23 | 10.67 | 31.2 | 35 | 6.7 | 6.3 |
| | | 6E | 4.17 | 10.17 | 30.2 | 34.1 | 7.3 | 7.1 |
| | | Average | 3.69 | 10.68 | 30.4 | 34.5 | 7.2 | 7.3 |
| | *Compost* | 6H | 3.4 | 7.17 | 30.5 | 34.4 | 6.9 | 7.7 |
| | | 6F | 0.57 | 8.93 | 29.2 | 34 | 7.4 | 7.6 |
| | | 5C | 4.43 | 12.63 | 29.7 | 34.4 | 7.5 | 8.1 |
| | | 5F | 0.43 | 7.07 | 29.8 | 33.9 | 7.1 | 7.5 |
| | | Average | 2.21 | 8.95 | 29.8 | 34.2 | 7.2 | 7.7 |
| | *Fertilizer* | 5J | 0.7 | 8.6 | 29.5 | 34.6 | 7.3 | 8 |
| | | 6D | 0.77 | 6.67 | 29.5 | 34.5 | 7.2 | 6.9 |
| | | 4H | 0.43 | 1.63 | 29 | 33.3 | 7.6 | 7.9 |
| | | 4J | 1.93 | 10.97 | 30 | 34.1 | 7.6 | 7.6 |
| | | Average | 0.96 | 6.97 | 29.5 | 34.1 | 7.4 | 7.6 |
| #1 | | | | | | | | |
| | *Yeast* | 5E | 2.37 | 5.1 | 29.5 | 30.5 | 7.4 | 7.8 |
| | | 5B | 3.43 | 7.13 | 29.1 | 30.1 | 6.5 | 6.8 |
| | | 6A | 4.9 | 5.9 | 30.1 | 30.7 | 7.7 | 8.1 |
| | | 6E | 2 | 7.2 | 29.3 | 30.2 | 7.9 | 8.7 |
| | | Average | 3.18 | 6.33 | 29.5 | 30.4 | 7.4 | 7.9 |
| | *Compost* | 6H | 4.6 | 12.1 | 29.3 | 30.3 | 8.1 | 9.1 |
| | | 6F | 0.6 | 2.7 | 29.5 | 30.4 | 7.9 | 8.7 |
| | | 5C | 3.8 | 7.63 | 29 | 30.2 | 7 | 7.5 |
| | | 5F | 1.43 | 4.13 | 29.7 | 30.6 | 7.4 | 7.9 |
| | | Average | 2.61 | 6.64 | 29.4 | 30.4 | 7.6 | 8.3 |
| | *Fertilizer* | 5J | 0.7 | 3.7 | 29.2 | 30.6 | 8.1 | 9 |
| | | 6D | 1.9 | 6.6 | 29.3 | 30.1 | 7.8 | 8.5 |
| | | 4H | 0.33 | 4.33 | 28.9 | 30.2 | 7.4 | 7.9 |
| | | 4J | 0.3 | 3.77 | 29.5 | 30.8 | 7.5 | 7.9 |
| | | Average | 0.81 | 4.6 | 29.2 | 30.4 | 7.7 | 8.3 |

Table 3a. Continued.

| Sample # | Treatment | Pond | Dissolved Oxygen ($mg\ l^{-1}$) | | Temperature (°C) | | pH | |
|---|---|---|---|---|---|---|---|---|
| | | | *AM* | *PM* | *AM* | *PM* | *AM* | *PM* |
| #2 | | | | | | | | |
| | *Yeast* | 5E | 4.3 | 14.27 | 29.8 | 33.7 | 9.5 | 9 |
| | | 5B | 5.03 | 15.2 | 29.1 | 15.2 | 8.4 | 9 |
| | | 6A | 6 | 9.7 | 30.3 | 33.2 | 7.5 | 7.8 |
| | | 6E | 3.2 | 14.3 | 29.9 | 33.7 | 7.8 | 8.4 |
| | | Average | 4.63 | 13.37 | 29.8 | 29 | 8.3 | 8.6 |
| | *Compost* | 6H | 0.7 | 10.5 | 29.6 | 33.4 | 8.2 | 8.7 |
| | | 6F | 0.7 | 12.6 | 29.8 | 34.1 | 7.8 | 8.4 |
| | | 5C | 5.07 | 16.63 | 29 | 16.6 | 9.5 | 9 |
| | | 5F | 2.63 | 8.9 | 30 | 34.1 | 8.7 | 8.8 |
| | | Average | 2.28 | 12.16 | 29.6 | 29.6 | 8.5 | 8.7 |
| | *Fertilizer* | 5J | 1.4 | 12.4 | 30 | 34.5 | 8.2 | 8.8 |
| | | 6D | 1.6 | 14.3 | 29.6 | 33.6 | 7.6 | 8.2 |
| | | 4H | 0.67 | 10.63 | 29.6 | 34.2 | 8.4 | 8.7 |
| | | 4J | 1.2 | 15.03 | 29.9 | 34.4 | 8.3 | 8.7 |
| | | Average | 1.22 | 13.09 | 29.8 | 34.2 | 8.1 | 8.6 |
| #3 | | | | | | | | |
| | *Yeast* | 5E Yeast | 3.27 | 8.63 | 27.2 | 30 | 7.8 | 9.1 |
| | | 5B Yeast | 3 | 7.43 | 27.2 | 30.1 | 7.6 | 8.9 |
| | | 6A Yeast | 4.7 | 8.8 | 27.8 | 30.1 | 6.9 | 7.9 |
| | | 6E Yeast | 2.7 | 11 | 27.3 | 30.8 | 7.9 | 9.2 |
| | | Average | 3.42 | 8.97 | 27.4 | 30.3 | 7.6 | 8.8 |
| | *Compost* | 6H Compost | 2.5 | 8.9 | 27.2 | 30.5 | 7.7 | 9.1 |
| | | 6F Compost | 1.3 | 8.9 | 27.4 | 30.9 | 7.5 | 8.6 |
| | | 5C Compost | 3.57 | 9.17 | 27.2 | 30.1 | 8 | 9.2 |
| | | 5F Compost | 2.87 | 8 | 27.5 | 30.1 | 7.5 | 8.7 |
| | | Average | 2.56 | 8.74 | 27.3 | 30.4 | 7.7 | 8.9 |
| | *Fertilizer* | 5J Fert | 2.3 | 8.1 | 27.2 | 30.7 | 7.3 | 9.2 |
| | | 6D Fert | 2.4 | 12.6 | 27.2 | 30.9 | 7.6 | 9 |
| | | 4H Fert | 0.87 | 6.67 | 27.2 | 30.3 | 7.2 | 8.2 |
| | | 4J Fert | 1.23 | 10.4 | 27.2 | 30.5 | 7.4 | 9.3 |
| | | Average | 1.7 | 9.44 | 27.2 | 30.6 | 7.4 | 8.9 |

Table 3b. Results of intial water sampling (average of each parameter).

| Sample # | Treatment | Pond | SDV | | Alkalinity | TAN (ppm) | P (ppm) |
|---|---|---|---|---|---|---|---|
| | | | *AM* | *PM* | | | |
| #0 | | | | | | | |
| | *Yeast* | 5E | 51 | 59 | 289 | 0 | 0.34 |
| | | 5B | 51 | 46 | 298 | 0 | 0.54 |
| | | 6A | 58 | 67 | 270 | 0.02 | 0.43 |
| | | 6E | 66 | 63 | 236 | 0.04 | 0.15 |
| | | Average | 56 | 59 | 273 | 0.01 | 0.36 |
| | *Compost* | 6H | 63 | 53 | 272 | 0.03 | 0.09 |
| | | 6F | 50 | 50 | 275 | 0.05 | 0.28 |
| | | 5C | 32 | 32 | 263 | 0.02 | 0.47 |
| | | 5F | 58 | 54 | 304 | 0 | 0.43 |
| | | Average | 51 | 47 | 279 | 0.02 | 0.32 |
| | *Fertilizer* | 5J | 44 | 60 | 304 | 0.01 | 0.64 |
| | | 6D | 63 | 65 | 288 | 0.02 | 0.5 |
| | | 4H | 62 | 50 | 279 | 0.02 | 0.17 |
| | | 4J | 65 | 67 | 279 | 0 | 0.5 |
| | | Average | 59 | 61 | 288 | 0.01 | 0.45 |
| #1 | | | | | | | |
| | *Yeast* | 5E | 45 | 39 | 203 | 0.01 | 0.4 |
| | | 5B | 21 | 26 | 184 | 0.01 | 0.1 |
| | | 6A | 79 | 66 | 182 | 0.01 | 0.34 |
| | | 6E | 36 | 35 | 177 | 0.01 | 0.31 |
| | | Average | 45 | 42 | 187 | 0.01 | 0.29 |
| | *Compost* | 6H | 33 | 34 | 182 | 0.02 | 0.19 |
| | | 6F | 63 | 63 | 217 | 0.02 | 0.24 |
| | | 5C | 19 | 22 | 159 | 0.1 | 0.35 |
| | | 5F | 55 | 53 | 220 | 0 | 0.57 |
| | | Average | 43 | 43 | 195 | 0.04 | 0.34 |
| | *Fertilizer* | 5J | 43 | 43 | 162 | 0.01 | 0.66 |
| | | 6D | 41 | 41 | 187 | 0.01 | 0.23 |
| | | 4H | 46 | 47 | 221 | 0 | 0.3 |
| | | 4J | 49 | 29 | 214 | 0 | 0.58 |
| | | Average | 45 | 40 | 196 | 0.01 | 0.44 |

Table 3b. Continued.

| Sample # | Treatment | Pond | SDV | | Alkalinity | TAN (ppm) | P (ppm) |
|---|---|---|---|---|---|---|---|
| | | | *AM* | *PM* | | | |
| #2 | | | | | | | |
| | *Yeast* | 5E | 29 | 28 | 202 | 0.01 | 0.54 |
| | | 5B | 23 | 14 | 176 | 0.03 | 0.08 |
| | | 6A | 69 | 51 | 193 | 0.05 | 0.27 |
| | | 6E | 41 | 38 | 183 | 0.03 | 0.25 |
| | | Average | 40 | 33 | 189 | 0.03 | 0.28 |
| | *Compost* | 6H | 42 | 41 | 170 | 0.05 | 0.52 |
| | | 6F | 35 | 33 | 237 | 0.06 | 0.18 |
| | | 5C | 19 | 18 | 160 | 0.05 | 0.35 |
| | | 5F | 50 | 49 | 227 | 0 | 0.57 |
| | | Average | 37 | 35 | 199 | 0.04 | 0.4 |
| | *Fertilizer* | 5J | 29 | 26 | 155 | 0.01 | 0.37 |
| | | 6D | 56 | 37 | 226 | 0.02 | 0.34 |
| | | 4H | 35 | 45 | 213 | 0.02 | 0.18 |
| | | 4J | 31 | 28 | 228 | 0.04 | 0.23 |
| | | Average | 38 | 34 | 206 | 0.02 | 0.28 |
| #3 | | | | | | | |
| | | 5E | 27 | 26 | 162 | 0.11 | 0.27 |
| | *Yeast* | 5B | 25 | 31 | 142 | 0.13 | 0.07 |
| | | 6A | 86 | 89 | 120 | 0.07 | 0.18 |
| | | 6E | 34 | 26 | 192 | 0.09 | 0.21 |
| | | Average | 43 | 43 | 154 | 0.1 | 0.18 |
| | *Compost* | 6H | 44 | 43 | 133 | 0.1 | 0.35 |
| | | 6F | 37 | 37 | 187 | 0.07 | 0.18 |
| | | 5C | 24 | 21 | 152 | 0.13 | 0.34 |
| | | 5F | 36 | 33 | 190 | 0.06 | 0.45 |
| | | Average | 35 | 34 | 166 | 0.09 | 0.33 |
| | *Fertilizer* | 5J | 21 | 24 | 135 | 0.12 | 0.2 |
| | | 6D | 30 | 31 | 270 | 0.08 | 0.48 |
| | | 4H | 34 | 30 | 187 | 0.08 | 0.13 |
| | | 4J | 27 | 21 | 177 | 0.17 | 0.32 |
| | | Average | 28 | 27 | 192 | 0.11 | 0.28 |