# Evaluation of Low Cost Supplemental Diets for Culture of *Oreochromis Niloticus* (L.) in North Vietnam (Part I)—Formulation of Supplemental Diets

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*Thailand Special Topics Research 3*

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## Introduction

With more than 400,000 hectares of inland waters, Vietnam possesses a great potential for freshwater fish culture (Asian Development Bank/FAO, 1992). However, most fish farming systems are extensive polyculture of Chinese carps. In recent years, the growing demand for fish in domestic markets has encouraged Vietnamese fish farmers to intensify pond culture. Many of them now are trying to expand from a grass carp (*Ctenopharyngodon idella*) based polyculture to achieve higher yields with Nile tilapia (*Oreochromis niloticus*) (Ha Noi Extension Center, 1996).

Nile tilapia was imported from Thailand to North Vietnam in 1994. In a few years, this species has quickly gained popularity among most northern fish farmers due to its fast growth and attractive appearance. However, overwintering fish remains a problem in the northern region, often forcing tilapia farmers to harvest their fish before the winter. In this situation, farmers need to achieve fast fish growth within a limited period of cultivation.

Supplemental feeding in fertilized ponds results in faster fish growth and higher pond yields at high stocking density compared to ponds that receive only fertilization (Hepher, 1963; Tacon, 1988). At present few studies of supplemental feeding of Nile tilapia have been conducted in Vietnam. Most farmers use only rice bran for fish feeding and economic returns from this feeding practice still remain questionable. Although studies on this issue have been carried out in some countries (Guerrero, 1980; Middendorn and Verreth, 1991;

Table 1. Formulas and costs of the experimental diets.

| Treatment Diet | Formulation | Feed Cost (US$ $kg^{-1}$) |
|---|---|---|
| T1 | Chicken feed brand C23A (20% protein) produced by Pronconco Company. | 0.48 |
| T2 | Chicken feed brand C20 (40% protein) mixed with corn meal. | 0.35 |
| T3 | Chicken feed brand C20 (40% protein) mixed with cassava meal. | 0.33 |
| T4 | Chicken feed brand C20 (40% protein) mixed with rice bran | 0.31 |
| T5 | Fish meal brand Kien Giang (50.4% protein) mixed with corn meal. | 0.28 |
| T6 | Fish meal bran Kien Giang (50.4% protein) mixed with cassava meal. | 0.27 |
| T7 | Fish meal bran Kien Giang (50.4% protein) mixed with rice bran. | 0.26 |
| T8 | Corn meal (11.2% protein) | 0.02 |
| T9 | Rice bran (8.7% protein) | 0.19 |

Green, 1992; Diana et al. 1994), few of them are applicable to Vietnam due to differences in the natural environment and socioeconomic conditions. Economically feasible diets need to be developed in Vietnam using locally-available ingredients such as rice bran, corn meal, cassava meal, fish meal, and chicken feed. The objective of this study was to develop practical supplemental diets for the culture of Nile tilapia in North Vietnam. Part I of this two-paper series focused on the selection of good supplemental diets, and Part II concentrated on determining the economically optimal feeding rate of the selected diet for tilapia raised in fertilized ponds.

## Methods and Materials

The experiment was carried out at the Research Institute for Aquaculture No. 1, located approximately 14 km northeast of Hanoi. Cages were constructed of metal frames and 1.5-cm mesh nylon net. Twenty-seven net cages, each 1 x 1 x 1.2 m (W x L x H), were placed 1 m into water, giving a submerged volume of 1 $m^3$ and suspended 20 cm above the pond bottom. The cages were arranged into three blocks in a 1000-$m^2$ earthen pond.

Nile tilapia of the Chitralada strain, offspring of the stock imported from Thailand in 1994, were used in this study. Sex-reversed, all male fingerlings (produced at the Research Institute for Aquaculture No.1) with a mean weight of 8.4 g were stocked in cages at a density of 25 fish $m^{-3}$.

Nine supplemental diets (Table 1) were formulated using locally-available materials of various costs. Feeds were compressed into pellets by a hand-powered extruder. Inorganic fertilizers (urea and superphosphate) purchased from local markets were applied at a rate of 28 kg N and 7 kg P $ha^{-1}$ $wk^{-1}$. Over a 90-day culture period (April to July 1996) feed was given daily at a rate that decreased with fish growth from 15% to 3% of body weight. Feed ration was placed in feeding trays which were suspended at mid depth in each cage. Rations were adjusted daily for each cage.

Weather data (solar radiation, air temperature, hours of sunshine, rainfall, humidity, and wind speed) were gathered daily by the Ha Noi Meteorological Station nearby. Water temperature and dissolved oxygen (DO) were measured daily at 06:30 h using a Yellow Spring Instrument (YSI) DO meter. DO and temperature were measured at two depths: 15 cm below the water surface and 15 cm above the cage bottom. Secchi disk visibility, chlorophyll *a*, pH, alkalinity, total ammonia, nitrate, nitrite, orthophosphate, total phosphorus, and solids were measured weekly. Visibility was calculated as the average depth at which the Secchi disk disappeared when lowered, and the depth at which it reappeared when raised (Boyd and Tucker, 1992). Chlorophyll *a* was analyzed using spectrophotometric method (APHA, 1980). Alkalinity and concentrations of total ammonia, nitrate, nitrite, orthophosphate, and total phosphorus in water were determined using standard methods (APHA, 1980): alkalinity was determined by titration with $H_2SO_4$ (0.02 N); total ammonia was measured by phenate method, nitrate was measured by cadmium reduction method, nitrite was measured by colorimetric method using diazotizing reagents, orthophosphate was measured by ascorbic acid reduction method, and total phosphorus was measured by persulfate digestion method (APHA, 1980). Proximate analyses of harvested fish carcass were completed according to the AOAC (1990).

To obtain survival and fish growth data the stock of each cage was counted and weighed every two weeks beginning with the initial stocking. Daily weight gain (DWG) was calculated using the following formula: DWG (g $fish^{-1}$ $day^{-1}$) = (final weight - initial weight)/number of days in culture period. Feed conversion ratio (FCR) was calculated as feed given per kilogram of wet weight gain.

Analysis of variance (ANOVA) was used to determine differences between treatments in mean final weight, production, daily weight gain, feed conversion ratio, survival rate, and protein content of carcasses of harvested fish. Duncan's multiple range test was used for screening the best treatments (Gomez and Gomez, 1984). A simple economic comparison was made to identify the most cost-effective diet.

## Results

### Climate

The study site, located in the Red River delta of Vietnam, has a subtropical climate which is dry and cool in the winter and moist and hot in the summer (The Fisheries Master Plan Project, 1996). During the experimental period (from late April to late July 1996) solar radiation, sunshine, and air temperature gradually increased and peaked in week 6 (mid June). The average solar radiation over the experimental period was 7,157 W $m^{-2}$ $d^{-1}$, sunshine was 4.4 hours $d^{-1}$, and temperature was 28.3°C. Rainfall also increased and was heaviest in the last two months of the experiment (June-July). Over the experimental period, the average rainfall was 37.5 mm $wk^{-1}$, evaporation rate was 2.9 mm $d^{-1}$, humidity was 78.2%, and wind speed was 2.4 m $s^{-1}$.

### Water Quality Parameters

There were no significant differences in water quality parameters between treatments ($P > 0.05$). Similar to air temperature, water temperature also gradually increased over time, from 20°C in the first week to 28 to 33°C for the remaining experimental period. The mean water temperature over the experimental period was 29.2°C. Secchi disk depth decreased gradually with time, ranging from 20 to 40 cm. Water pH was relatively stable, ranging from 6.9 to 8.3. Early morning dissolved oxygen (DO) ranged from 2 to 3 mg $l^{-1}$ in the first 9 weeks and decreased to 0.5 to 1.0 mg $l^{-1}$ in the last 3 weeks. Alkalinity decreased slightly over time, ranging from 76 to 117 mg $CaCO_3$ $l^{-1}$. Total ammonia concentration significantly increased, beginning with week 7, and ranged from 0.19 to 0.5 mg $l^{-1}$ over the whole period. Nitrite concentration ranged from 0.001 to 0.02 mg $l^{-1}$ with the exception of week 8 when it reached 0.05 mg $l^{-1}$. Nitrate concentration ranged from 0 to 0.8 mg $l^{-1}$; orthophosphate concentration ranged from 0.013 to 0.2 mg $l^{-1}$; total phosphorus ranged from 0.1 to 0.4 mg $l^{-1}$; chlorophyll *a* concentration ranged from 97 to 200 mg $m^{-3}$; total solids ranged from 100 to 400 mg $l^{-1}$; total dissolved solids ranged from 90 to 320 mg $l^{-1}$; total suspended solids ranged from 12 to 70 mg $l^{-1}$; total volatile dissolved solids from 33 to 255 mg $l^{-1}$; and non-filterable volatile solids ranged from 9 to 33 mg $l^{-1}$.

### Fish Growth Performance and Economic Comparison

There were significant differences among the experimental diets in fish growth rate and production ($P < 0.01$), but not in survival rate nor crude protein content of carcasses of harvested fish ($P > 0.05$) (Figure 1 and Table 2). During the 90-day culture period the diet containing 20% crude protein formulated from concentrated chicken feed (40% crude protein) and cassava meal (T3) resulted in the fastest growth of tilapia (mean individual weight at harvest of 180.2 g and daily weight gain of 1.91 g) followed by the diet of chicken feed brand C23A, containing 20% crude protein (T1) (mean individual weight at harvest of 170.4 g and daily weight gain of 1.82 g). These two diets also resulted in the highest fish production and lowest feed conversion ratios. The treatments with diets formulated from fish meal and cassava meal (T6), from fish meal and corn meal (T5), and from chicken concentrated feed and rice bran (T4) gave intermediate fish growth rates and yields. Corn meal (T8) and rice bran (T9) produced the slowest fish growth and highest FCRs.

An economic comparison showed that the diet formulated from concentrated chicken feed and cassava meal (T3) had the highest net profit and returns to investment (Figures 2 and 3). This diet had relatively high feed investment per unit of cultured area but the lowest break even price

Table 2. Comparison of fish growth performance in response to various experimental diets over a 90-day culture period.

| Treatments | Stocking Weight (g fish$^{-1}$) | Harvesting Weight (g fish$^{-1}$) | Daily Weight Gain (g fish$^{-1}$ d$^{-1}$) | Fish Production (kg m$^{-3}$) | Feed Conversion Ratio |
|---|---|---|---|---|---|
| T1 | 8.4$^{a}$ | 172.4$^{ab}$ | 1.82$^{ab}$ | 4.04$^{ab}$ | 1.63$^{ab}$ |
| T2 | 8.4$^{a}$ | 158.2$^{bc}$ | 1.66$^{bc}$ | 3.65$^{ab}$ | 1.77$^{ab}$ |
| T3 | 8.4$^{a}$ | 180.2$^{a}$ | 1.91$^{a}$ | 4.17$^{a}$ | 1.64$^{a}$ |
| T4 | 8.4$^{a}$ | 150.1$^{c}$ | 1.57$^{c}$ | 3.40$^{abc}$ | 1.81$^{ab}$ |
| T5 | 8.4$^{a}$ | 141.9$^{c}$ | 1.48$^{c}$ | 3.34$^{abc}$ | 1.94$^{ab}$ |
| T6 | 8.4$^{a}$ | 137.1$^{c}$ | 1.43$^{c}$ | 3.13$^{bcd}$ | 1.83$^{ab}$ |
| T7 | 8.4$^{a}$ | 138.0$^{c}$ | 1.44$^{c}$ | 2.59$^{cd}$ | 2.92$^{d}$ |
| T8 | 8.4$^{a}$ | 100.8$^{d}$ | 1.03$^{d}$ | 2.25$^{d}$ | 2.55$^{bc}$ |
| T9 | 8.4$^{a}$ | 106.4$^{d}$ | 1.09$^{d}$ | 2.27$^{d}$ | 2.56$^{bc}$ |

[abcd] Treatments annotated with the same superscript are not significantly different ($P > 0.05$)

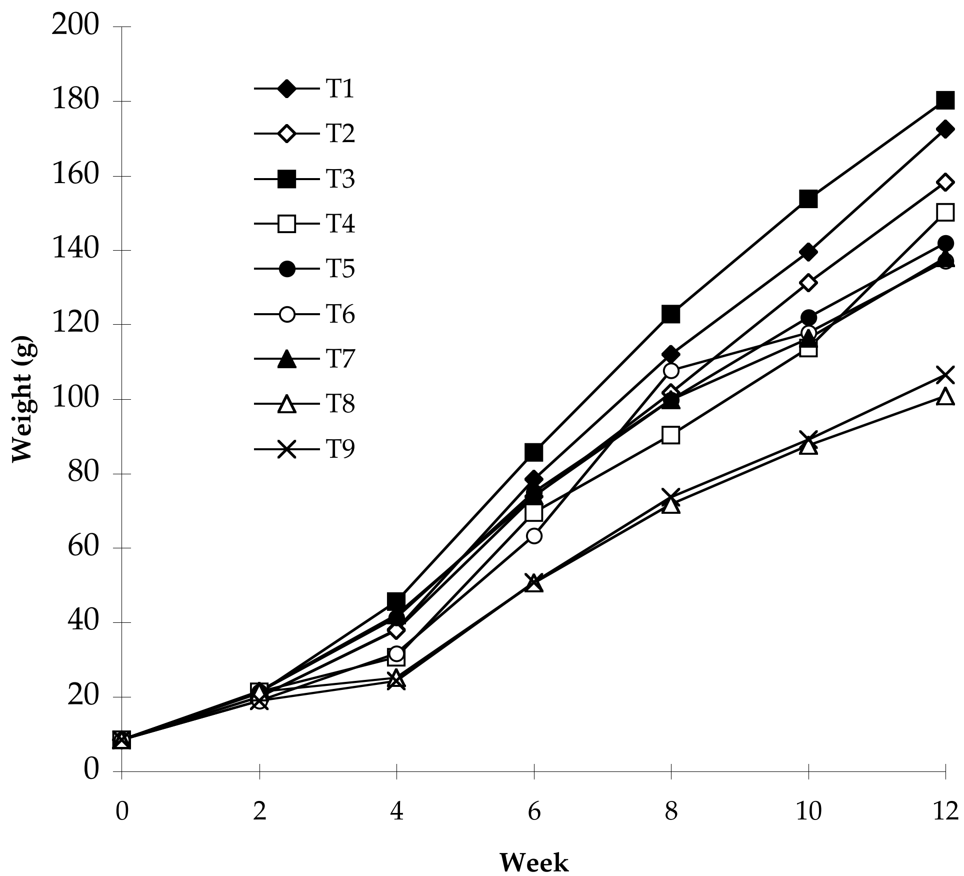


Figure 1. Fish growth curves in response to various experimental diets over a 90-day culture period.

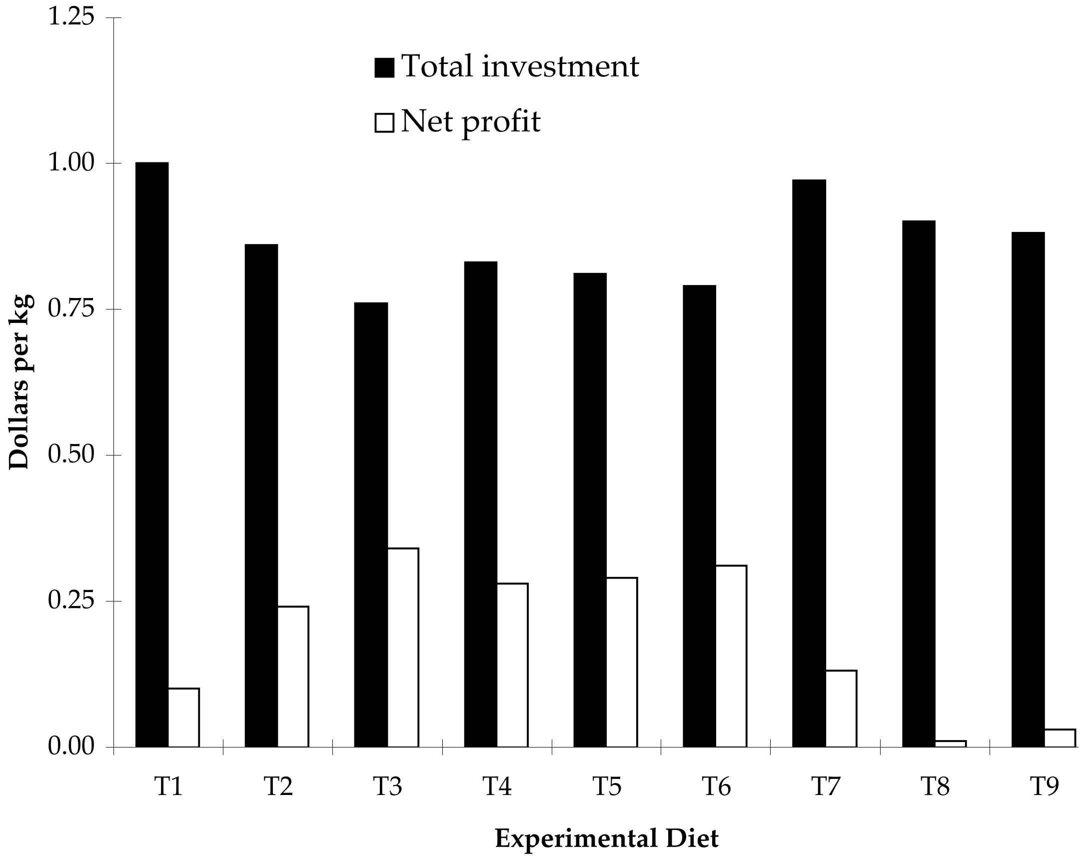


Figure 2. Comparison of net profit and total investment per kg of fish produced among the experimental diets.

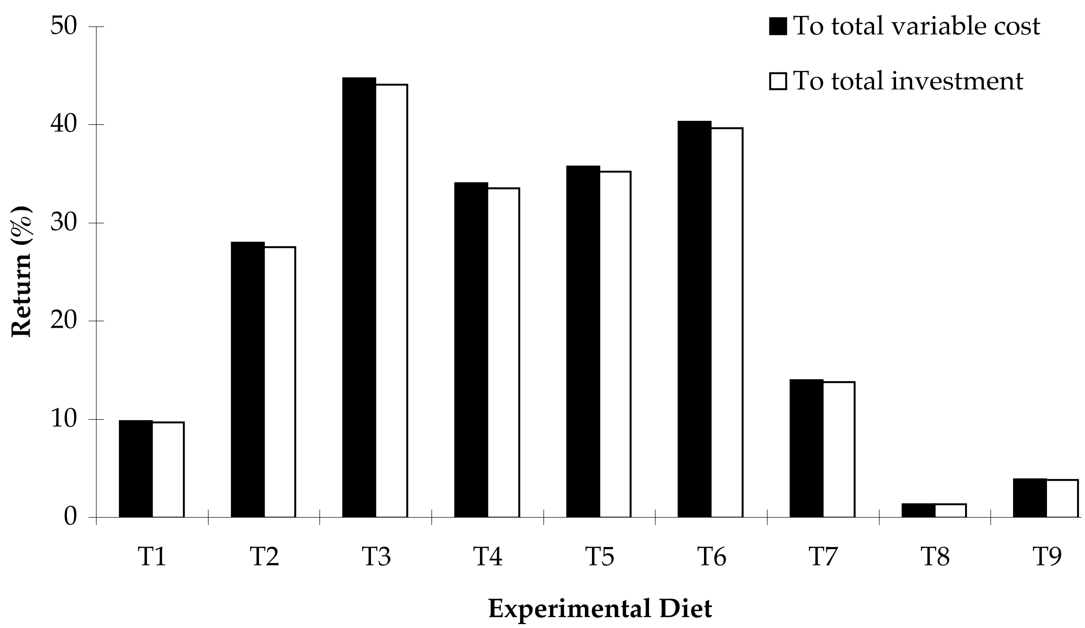


Figure 3. Comparison of returns to variable cost and to total investment among the experimental diets.

Table 3. Simple economic comparisons among the experimental diets for a 1 $m^3$ cage.

| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 |
|---|---|---|---|---|---|---|---|---|---|
| **Harvest** | | | | | | | | | |
| Biomass Harvested (kg) | 4.25 | 3.85 | 4.38 | 3.60 | 3.55 | 3.33 | 2.75 | 2.46 | 2.47 |
| Unit Price ($ $kg^{-1}$)[a] | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 0.91 | 0.91 |
| Total Revenue ($) | 4.68 | 4.24 | 4.82 | 3.96 | 3.91 | 3.66 | 3.03 | 2.24 | 2.25 |
| **Variable Costs**[b] | | | | | | | | | |
| Fish Seed ($) | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Feed ($) | 3.17 | 2.24 | 2.26 | 1.89 | 1.81 | 1.55 | 1.59 | 1.15 | 1.10 |
| Urea ($) | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| Superphosphate ($) | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Lime ($) | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Total Variable Costs ($) | 4.20 | 3.27 | 3.30 | 2.92 | 2.85 | 2.58 | 2.62 | 2.18 | 2.13 |
| Interest ($) | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 |
| Total Cost per 1 $m^3$ Cage ($) | 4.26 | 3.32 | 3.34 | 2.97 | 2.89 | 2.62 | 2.66 | 2.21 | 2.17 |
| Gross Margin per $m^3$ Cage ($) | 0.48 | 0.96 | 1.52 | 1.04 | 1.06 | 1.08 | 0.40 | 0.06 | 0.11 |
| Net Profit per 1 $m^3$ Cage ($) | 0.41 | 0.91 | 1.47 | 0.99 | 1.02 | 1.04 | 0.37 | 0.03 | 0.08 |
| Total Investment per 1 kg Fish ($ $kg^{-1}$) | 1.00 | 0.86 | 0.76 | 0.83 | 0.81 | 0.79 | 0.97 | 0.90 | 0.88 |
| Net Profit per 1 kg Fish ($ $kg^{-1}$) | 0.10 | 0.24 | 0.34 | 0.28 | 0.29 | 0.31 | 0.13 | 0.01 | 0.03 |
| Return to Total Variable Cost (%) | 9.80 | 27.95 | 44.71 | 34.00 | 35.72 | 40.26 | 13.96 | 1.31 | 3.86 |
| Return to Total Investment (%) | 9.68 | 27.54 | 44.05 | 33.50 | 35.19 | 39.66 | 13.75 | 1.29 | 3.80 |

[a] The prices for fish larger and smaller than 110 g were US$ 1.10 and US$ 0.9 $kg^{-1}$, respectively.
[b] For the experimental scale (a few small cages), labor cost was not included in the analysis.

(total investment per kg of fish produced) due to its high production. The diet formulated from fish meal and cassava meal (T6) had the second highest net profit followed by the diets derived from fish meal and corn meal (T5) and from concentrated chicken feed and rice bran (T4). Compared to the other diets chicken feed brand C23A (T1) had high fish production but low net profit due to its high feed cost. Treatments of corn meal (T8) or rice bran (T9) alone yielded the lowest profits and returns to investment. Although these two treatments were the least expensive, their break even prices were very high due to low fish production.

An overall comparison indicated that the diet containing 20% crude protein derived from concentrated chicken feed (40% crude protein) and cassava meal (T3) was the most economical for tilapia farming in North Vietnam, followed by the diets derived from fish meal and cassava meal (T6), from fish meal and corn meal (T5), and from concentrated chicken feed and rice bran (T4).

## Discussion

Nile Tilapia is considered a prime species for culture in tropical and subtropical regions, because it has a fast growth rate and adapts to a wide range of environmental conditions. In the present study, climatic and water quality parameters varied within acceptable ranges for normal growth of tilapia. Differences in water quality parameters between treatments were not significant ($P > 0.05$) implying that all experimental diets were environmentally suitable for tilapia culture.

Tilapia feed on a large variety of natural food organisms found in fertilized ponds (Yashouv and Chervinski, 1961; Bowen, 1982; Trewavas, 1983); however, their growth rate decreases once the critical standing crop in fertilized ponds has been attained, because the quantity of natural food can no longer support rapid growth (Tacon, 1988). Supplemental feeding at this time permits fish to continue to grow rapidly (Hepher, 1978). In North Vietnam where a long, cold winter prevails and culture periods are shorter, the use of supplemental feed is required to improve the harvest size of tilapia. However, feed is often 60% or more of total production cost so that feed cost reductions can substantially increase the profitability of a culture system. In Thailand chicken pellets (19.9% crude protein) were experimentally determined to be a suitable supplemental feed for the cage culture (Chiayvareesajja et al., 1988). During a five-month culture period Nile tilapia increased from an initial weight of 13.5 g to a final weight of 108.7 g with a yield of 3.43 kg $m^{-3}$. In the Philippines, Guerrero (1980) indicated that diets with 25% fishmeal and 75% fine rice bran or 25% fishmeal, 10% copra meal, and 65% rice bran were economical for cage culture of Nile tilapia.

In the present study the diet containing 20% crude protein formulated from concentrated chicken feed (40% crude protein) and cassava meal (T3) was found to give the best growth of Nile tilapia. The data in Table 2 shows a trend indicating that all treatment diets using concentrated chicken feed as a main source of protein resulted in faster growth rates and higher production than the treatment diets using fish meal; however, the differences were not statistically significant ($P > 0.05$). This trend may be due to micronutrients that have been added to concentrated chicken feeds by producers. Table 2 data also indicates that all diets containing rice bran have slower growth rates and lower production than the diets containing cassava or corn meals. This finding may be related to the quality of rice bran purchased in local markets. Large amounts of rice bran sold in Ha Noi were imported from the Southern region (the Mekong delta). Fish kills observed locally may be attributable to feeding rice bran that may have spoiled during lengthy transportation from the south, or during storage under conditions of high humidity in the north.

Economic comparison of treatments (Table 3) favored the utilization of formulated feeds for Nile tilapia culture rather than single-ingredient feeds, (i.e., corn meal or rice bran) that are widely used in Vietnam. Rice bran or corn meal alone resulted not only in low production and profit but also in a high break even price. Results from this study indicate that using the appropriate formulated diets as supplemental feed for Nile tilapia in fertilized ponds is profitable in North Vietnam. In the present study the highest profit (US$ 0.34 $kg^{-1}$ fish) was achieved when fish were fed a 20% crude protein diet derived from concentrated chicken feed (40% crude protein) and cassava meal (T3). This diet had the lowest break-even price but required a relatively high total feed investment per unit of area cultured. The diets formulated from fish meal and cassava meal (T6), fish meal and corn meal (T5), and concentrated chicken feed and rice bran (T4) were suggested as viable alternatives for farmers who require feeds with lower investment costs but relatively high net profits and returns.

## Anticipated Benefits

The use of supplemental feeds to facilitate faster tilapia growth under colder climates is a major production practice in Vietnam. This study provides evidence that supports the use of locally available waste products and feed materials in tilapia production rather than the use of remotely prepared feeds which are expensive to use and difficult to transport. As such, this study has immediate usefulness in the profitability of tilapia culture locally. The results of this study will be widely tested by aquaculturists and extension personnel to improve grow out conditions and profitability. It will also lead to further experimentation on feed development and efficient feeding systems. Such experimentation and extension will likely enhance the economic returns to tilapia farmers.

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