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Use of Low-Cost Aqua-Feed in Semi-Intensive Cage Culture of the Gift Strain of Nile Tilapia (*Oreochromis niloticus*)

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Abstract

The objective of this trial was evaluating the growth performance of GIFT Tilapia (*Oreochromis niloticus*) with 2 types of aqua-feeds(Feed-A and Feed-B) in cage culture and determine the suitability compared to the commercial fish feed (Feed-C) as control. Nine cages (10 m^3 each) were installed in a reservoir (80 ha) and stocked with fingerlings of GIFT Tilapia (mean weight= 18.7±12.07 g; mean total length 9.7±2.08 cm**)** at a density of 45 fingerlings m^{-3}. Completely Randomized Design with 3 treatments, in triplicate, was utilized. Rice bran, Poonac and fishmeal (Fm) were used to formulate both aqua-feeds. Part of the Fm (10-12%) in Feed-B was replaced by fresh ipil-ipil leaves. The protein percentage (%) in Feed-A and Feed-B was adjusted to 29%, but it ranged from 17.20-23.97 and from 19.6-25.5, respectively. During the experimental period, fish were fed twice daily at 5% of body weight at the beginning and then up to 3.6%, 3% and 2.5% onwards. The mean % survival, Condition Factor and Specific Growth Rate of the fish fed on Feed-A, Feed-B and Feed-C were not significantly different ($P>0.05$), but the Average Daily Growth was significantly different ($P<0.05$). Data were analyzed with One-way ANOVA. The total fish production in cages through Feed-A, Feed-B and Feed-C were 128, 77 and 160 kg, respectively. Considering the cost of feed Rs.18/-, 17/- and 160/- and net income received in Rs. 18,645/-, 8140/-, (20,800/-), Feed-A and Feed-B could be considered. Nevertheless, as the ipil ipil leaves were the ingredient and considering the availability of the highest carcass protein content (18.878±2.193), Feed-B is economically feasible.

Keywords: Ipil ipil, fish feed, community involvement, cheap protein sources.

Introduction

Fish is the main animal protein source for Sri Lankans. The annual per capita fish consumption was 19 kg/head in 2010. The Medical Research Institute (MRI) of Sri Lanka recommended level was 21 kg/head (http://www.fisheriesdept.gov.lk/index.html, DF, 2015). According to Amarasinghe and De Silva, (1999), inland fish are the main source of animal protein for rural people living in the dry zone (1,870 mm rainfall annually) of Sri Lanka. Accordingly, the per capita fish consumption of the rural community could be increased further and could be reached to this level through the enhancement of inland fish production. It could be done through promoting semi-intensive aquaculture practices (pond, cage and pen culture) in rural areas. Particularly cage culture could be promoted due to the availability of many perennial reservoirs in dry zone of Sri Lanka. According to De Silva (1988), the total area of irrigation reservoirs available in Sri Lanka is about 175,000 ha *i.e*. about 2.7 ha for every km^2 of land area, which is one of the highest in the world.

Cage culture is successfully carried out in all the South Asian Countries, mainly semi-intensively. It is practiced extensively in Nepal with plankton feeding fish. Nevertheless, a little work was done with respect to food fish culture in cages in Sri Lanka. However, cage culture is being used mainly as a tool for fingerling production with community participation. As the prices of commercial feed are high, people use the mixture of rice bran (Rb) and poultry feed as fish feed in fingerling rearing in cage culture, as well as pond culture (Personnel observation in Dambulla area). Nevertheless, Red tilapia (*Oreochromis* spp.) culture in cages supplemented with Rb totally failed in Kiri-Ibbanwewa, Sri Lanka, due to the insufficient amount of Rb (Ariyaratne, M.H.S., Unpublished data). Wannigama *et al.* (1985) have shown that there was no significant difference in the growth rate and feed efficiency of cage reared *O. niloticus* (Nile tilapia) fingerling when fed at 29% protein diet or a 19% protein diet (containing 92% chicken mash) in Sri Lanka. However, feed cost is the highest operating

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cost in semi-intensive aquaculture practices in Asia (De Silva, 1989; De Silva and Anderson, 1995). The option should be the introduction of low-cost aqua-feed using locally available, agriculture and fisheries by-products for the semi-intensive aquaculture practices.

The selected fish species *Oreochromis niloticus* (GIFT strain) has shown to perform better than other strains of *O. niloticus* in pond and cage culture systems (Eknath *et al.*, 1993; Bentsen *et al.,* 1998; Dey *et al.,* 2000; Gupta and Acosta, 2004. Accordingly, this species was used in this trial as it necessary to use a better fish species to promote semi-intensive aquaculture practices in Sri Lanka.

The objective of this trial was evaluating the growth performance of GIFT Tilapia (*O. niloticus*) with locally prepared 2 aqua-feeds (Feed-A and Feed-B) in cage culture and determine the suitability compared to the commercial fish feed (Feed-C) as control.

Materials and Methods

Study Area

The study was conducted in Mahawewa, a perennial reservoir (80 ha), (6° 16´Latitude and 80° 13´ Longitude) in Hambantota District in the south of Sri Lanka from 02 October 2008 to 19 March 2009 (167 days).

Experimental Set up

Nine rectangular cages were made of 18 ply gill net material, measuring 1.8×3.6×1.8 m =9.72 $m^3 \approx 10$ m^3 for the water volume. The cages were fixed in to floating frame (prepared using S-lon tubes and supported with empty plastic cans (25 L). These soft cages were kept in proper shape using frames that prepared through ½" S-lon tubes when the cages were diploid in reservoir. *O. niloticus* (GIFT strain) was procured from the Freshwater Aquaculture Development Centre in Udawalawe, Sri Lanka. The advanced fingerlings with mean weight of 18.7±12.07 g and mean total length of 9.7±2.08 cm were stocked according to the stocking density of 45 fingerlings m^{-3}. Accordingly, 450 advanced fingerlings were stocked in each cage, respectively.

Nine families from the fisher community of the Fisheries co-operative society in Mahawewa were involved in making, installing, stocking, feeding, maintaining and harvesting cages, as the experiment was community based research. Mainly women fishers carried out the preparation of aqua-feed and feeding to fish. They were trained on these activities through "Farmer Field School Trainings"

Experimental Design

Two aqua-feeds (Feed-A & Feed-B) and the commercial feed (Feed-C) as control feed were tested in triplicate. Completely Randomized Design was used to select the cages for variables *i.e*. Feed-A, Feed-B and Feed-C.

Feed Preparation

Locally available raw materials: rice bran (Rb), coconut residue (CR) and local fishmeal (Fm) were included in both feed types as ingredients. This Fm was purchased from Colombo market and it was produced through dried small pelagic marine fish, Eubleekeria splendens (Cuvier, 1829) (splendid pony fish). The price is lower than imported Fm. Part of the Fm (10-12%) in Feed-B was replaced through adding crushed/ground fresh ipil-ipil leaves. Peeled off cassava (*Manihot esculenta*) tubes were boiled and prepared as forage to use as the binder. According to the Pearson's Square method, the percentage protein was adjusted around 29% in both feeds, respectively. Nevertheless, the actual % protein in Feed-A and Feed-B ranged between 17.20 to 23.97 and in 19.6 to 25.5, respectively, as feed preparation was done by the community *in situ*. Feed-C was purchased from the Ceylon Aquatech (Pvt) Limited, Rock House Lane, Colombo-15, Sri Lanka.

All the ingredients except fresh ipil-ipil leaves were prepared into powder form and the fine powders were separated using ordinary plastic sieve respectively. Feed was prepared according to the ratios of respective formulae of Feed-A and Feed-B (Table 1). The required amount of feed was

Table 1. Ingredient composition (%) and cost of the test feed (Feed-A & Feed-B) and control (Feed-C)

Feed-A	Feed-B	Feed-C
Rice bran	Rice bran	Cereals & Cereal by-products
Poonac	Poonac	Oilseed meals
Cassava	Cassava	Fish oil
Fishmeal	Fishmeal	Fish products
	Fresh Ipil ipil leaves	Other animal by-products
		Vitamins
		Minerals
		Permitted additives
Cost of Feed(Rs.)		
17/-	16/-	160/-

determined according to the fish biomass in the respective cages. The amount of fresh ipil-ipil leaves was crushed using motar and pestle and mixed thoroughly with other feed ingredients manually. Sufficient amounts of cooked cassava forage were added to prepare feed dough in respective feed types. Feed were prepared by the community daily *in situ*. The amount of feed was adjusted according to the total biomass in respective cages through biweekly sampling of the fish in the respective cage assuming no mortality. Sampling was carried out from the beginning until the trial was ended.

Feeding Fish

During this experimental period, fish were fed at 5% of body weight at the beginning of the trial up to 3.6%, 3% and 2.5% onward. Feed was provided twice daily, once in the morning ($08{:}^{00}$ hrs) and once in the evening (17:00 hrs).

Water Quality

Water quality parameters of pH and Temperature were measured biweekly using pH meter (Genway) and Glass Mercury thermometer. Water samples for the determination of Chlorophyll-a were collected monthly near to the cage culture site and analyzed using Shimadzu spectrophotometer (Model: DR 4000-USA) measuring the absorbance at 665 and 750 nm using 90% acetone. The concentration of Chlorophyll *a* (Ch.a) was calculated using the equation derived from Vollenweider (1969):

Chlorophyll-a ($\mu g\ L^{-1}$) = $11.9(A_{665}-A_{750})V/L \times 1000/S$

Proximate Analyses

The proximate compositions of Feed-A & Feed-B were determined 3 times and the commercial feed only once in triplicate through the culture period. Randomly selected five fish from initial sample and one fish from each cage in the final samples were sacrificed and used in proximate analysis of carcasses. Proximate analyses were done according to the standard methods in APHA (1985). The % moisture content was determined by oven drying weighed samples in porcelain crucibles at 105ºC for 24 hrs. The total volatile matter lost at this temperature was taken as the moisture content. The % ash content was determined by incinerating the dried samples overnight in a Muffle furnace at 550ºC. The % protein (N×6.25) was estimated by semi-micro Kjeldahl digestion, distillation and titration. The % fat was determined through chloroform method (Bligh and Dyer, 1959).

Growth Performance

The performance of the different diets were assessed in terms of Specific growth rate (SGR), Average Daily Growth (ADG), Condition Factor (K), Food Conversion Ratio (FCR), Protein Efficiency Ratio (PER) and % Survival as following equations and mean values (±SD) for each parameter were computed.

Statistical Analyses

The results for growth, as well as Feeds and protein utilization were compared by One-way ANOVA. Tukey's test was used to identify differences between treatments at 95% confidence level (P=0.05).

Results

The ADG of the fish fed on Feed-C (1.0761±0.2322 g day^{-1}) was significantly higher than the fish fed on Feed-A (0.7429±0.0925 g day^{-1}) and Feed-B (0.5076±0.0172 g day^{-1}), respectively (Table 2).The final mean weight (MW) of the fish that fed on Feed-C (198.4±49.89 g) was significantly different and significantly higher than the final mean body weight of the fish fed on Feed-A (142.8±59.6 g) and Feed-B (137.07±75.42 g). As such, the weight gain of the fish with Feed-C (179.7 g) was higher than with Feed-A (124.1 g) and Feed-B (118.37 g) (Table 2). The mean body weight of the fish fed on Feed-C has shown higher value throughout the culture period from day 16 – day 167, than the fish fed on Feed-A and Feed-B (Figure 1)

The percentage survival of the fish fed on Feed-A (60.74±19.65) and Feed-B (74.56±22.49) were significantly higher than the percentage survival of the fish fed on Feed-C (47.78±14.14), but not

Table 2. Growth performance of *Oreochromis niloticus* (GIFT strain) fed with 2 aqua-feeds (Feed-A and Feed-B) and Commercial feed (Feed-C); the control feed for 167 days in cage culture in Mahawewa, Hambantota District, Sri Lanka

	Feed-A	Feed-B	Feed-C
Average Daily Growth rate (g/day)	$0.7429^{a}\pm0.0925$	$0.5076^{a}\pm0.0172$	$1.0761^{b}\pm0.2322$
Specific Growth Rate	$1.2148^{c}\pm0.0659$	$1.1624^{c}\pm0.2394$	$1.4962^{c}\pm0.1731$
% Survival	$60.74^{d}\pm19.65$	$74.56^{d}\pm22.49$	$47.78^{d}\pm14.14$
Condition Factor	$2.3283^{e}\pm0.1109$	$2.2888^{e}\pm0.1905$	$2.2543^{e}\pm0.0250$
Mean Weight (Final) (g)	$142.76^{h}\pm15.48$	$133.73^{h}\pm52.49$	$198.4^{k}\pm38.75$
Mean Length (Final) (cm)	$18.3^{m}\pm0.9539$	$17.8^{m}\pm1.7321$	$20.6^{m}\pm1.2728$
Weight Gain (g)	$124.07^{n}\pm15.48$	$119.13^{n}\pm59.59$	$215.19^{n}\pm67.28$

significantly different (P>0.05) (Table 2).

The K and the SGR of the fish that fed on these 3 feed types were not significantly different respectively too (P>0.05) (Table 2). The overall health of the fish appeared normal.

The proximate composition of the used three feed types (Feed-A, Feed-B and Feed-C) are shown in Table 3. The percentage (%) of protein in Feed-A, Feed-B and Feed-C were significantly different and significantly higher in Feed-C than Feed-A and Feed-B (Table 3).

The initial and final carcass composition of the fish fed on Feed-A, Feed-B and Feed-C are presented in Table 4. The percentage (%) of protein in body flesh of fish fed on Feed-B (18.878±2.193) was higher than the fish fed on Feed-A (15.811±0.607) and fed on Feed-C (17.448±2.046). As such, the % fat in body flesh of the fish fed on Feed-B (0.3346±1.3081) was smaller than Feed-A (1.6381± 0.1158) and Feed-C (1.6873± 0.0259).

The mean and total fish production, total income and the total production cost through the cages provided with Feed-A, Feed-B and Feed-C were shown in Table 5. The cost of Feed-C is very high (Rs.160/-/kg) compared with the locally prepared Feed-A (Rs.17/-kg) and Feed-B (Rs.16/-kg).The gross income obtained from the fish fed on Feed-A, Feed-B and Feed-C was Rs.25,700.00, Rs.14,700.00 and Rs.32,000.00 respectively. However, due to the cost of feed the net income has been reduced up to Rs. (20,800.00).

The ADG and MW of the fish fed on these 3 feed types were significantly different (P<0.05) and significantly higher in the fish fed on Feed-C than Feed-A and Feed-B. However, the % survival, K and SGR of the fish fed on these 3 feed types were not significantly different (P>0.05). The %Dry matter, % Moisture, % protein and % Fat of the 3 feed types were significantly different (P<0.05) respectively but the % Ash was not significantly different (P>0.05). Although the % Ash in Feed-A (11.74) and Feed-B (11.71) was in little higher than Feed-C (8.81). The highest % protein and lowest % fat were recorded in body flesh of the fish fed on Feed B. The Gross income was higher while fish fed on Feed-C than fish fed on Feed-A and Feed-B. However, due to the high feed cost the net income has decreased and it was a loss (negative) while fish fed on Feed-C.

Discussion

The two aqua-feed (Feed-A & Feed-B) that were prepared through locally available ingredients could be used in the *O. niloticus* (GIFT strain) food fish culture in cages in Mahawewa, a perennial reservoir in Hambantota District in the dry zone of Sri Lanka. Considering the feed cost and net income received, Feed-A and Feed-B have shown attractive net income in food fish culture of GIFT Tilapia in cages in semi-intensive farming.

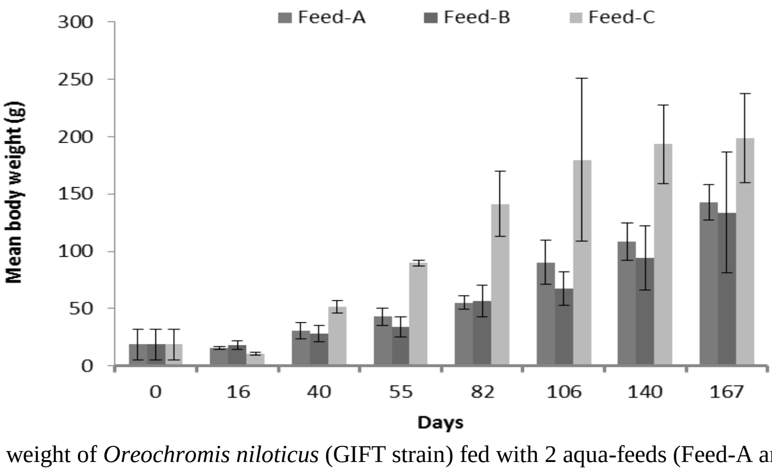

Figure 1. Mean body weight of *Oreochromis niloticus* (GIFT strain) fed with 2 aqua-feeds (Feed-A and Feed-B) and Commercial feed (Feed-C) for 167 days culture period in cages in Mahawewa, Hambantota District, Sri Lanka.

Table 3. Proximate composition of two aqua-feed (Feed-A and Feed-B) and the commercial feed (Feed-C) used for *Oreochromis niloticus* (GIFT strain) food fish culture in cages in Mahawewa in Hambantota, Sri Lanka

Proximate (%)	Feed-A	Feed-B	Feed-C
Dry matter	48.82^{a}±2.80	50.60^{a}±8.19	90.23^{b}±0.17
Moisture	51.18^{c}±2.80	49.40^{c}±8.19	9.77^{d}±0.17
Ash	11.74^{e}±2.98	11.71^{e}±4.48	8.81^{e}±0.14
Protein	20.58^{f}±4.77	22.5^{f}±4.14	32.5^{g}±1.13
Fat	3.08^{h}±0.97	2.47^{h}±0.39	8.64^{j}±0.09

Table 4. Proximate carcass composition of initial (start) and final sampling (end) of *Oreochromis niloticus* (GIFT strain) fed on 3 feed types (Feed-A, Feed-B and Feed-C) in cages in Mahawewa in Hambantota, Sri Lanka

	Fed on	% Dry matter	% Moisture	% Ash	% Protein	% Fat	% Carbohydrate
Initial sample		19.8753	80.1247	1.8564	15.6564	1.8820	0.4806
Final sample	Feed-A	19.673±0.172	80.327±0.172	1.6807±0.1468	15.811±0.607	1.6381±0.1158	0.6752±0.1188
	Feed-B	22.467±1.765	77.534±1.765	1.4890±0.0734	18.878±2.193	0.3346±1.3081	0.7918±0.0639
	Feed-C	21.711±1.787	78.229±1.787	1.9424±0.2773	17.448±2.046	1.6873±0.0259	0.6498±0.4679

Table 5. Profitability of cage culture of *Oreochromis niloticus* (GIFT strain) with 3 feed types (Feed-A, Feed-B and Feed-C)

	Feed-A	Feed-B	Feed-C
Feed cost (Rs.)	7,055.00	6,560.00	52,800.00
	(17 ×413.7)	(16× 407)	(160×330)
Mean fish production (kg/m^3)	4.3	3.85	5.33
Total fish production (kg)	128	77	160
Gross income (Rs.)	25,700.00	14,700.00	32,000.00
Net income (Rs.)	18,645.00	8,140.00	(20,800.00)

Fish fed on Feed-C grew faster than those fed with Feed-A and Feed-B. The main reason might be the higher protein content in the commercial feed (Table 3) compared to the used aqua-feeds, Feed-A and Feed-B. However, the price for Feed-C is very high (Rs.160/-) comparing with the two aqua-feeds (Table 1). Accordingly, the final income was minus value in Feed-C provided cages. Xie *et al.* (1998) have pointed out that the profit is minus with artificial diets due to the price of fish is low relative to that of feed ingredients as the major source of nutrients.

These two aqua-feeds were relatively low in protein: Feed-A (17.2 to 23.9%) and Feed–B (19.6 to 25.5%) compared to the used commercial feed (Feed-C 32.5±1.13). This may not be a major drawback for the growth of tilapia in floating cages as the fish could obtain part of the protein requirement through the utilization of natural food available in the reservoir. Wannigama *et al.* (1985) have observed that no significant difference in the growth rate and feed efficiency of cage reared fingerling Tilapia (*O. niloticus*) when fed a 29% protein diet or a 19% protein diet (containing 92% chicken mash) in floating cages in Udawalawe reservoir in Sri Lanka. According to the citation of Xie *et al.* (1998), tilapia under semi-intensive culture obtains substantial amounts of protein from natural food. As cited by Coche (1982), the natural food in pond contains about 55% protein on a dry weight basis and could be supplemented by carbohydrate rich feeds such as Rb. The chlorophyll *a* content in Mahawewa ranged between 21.43-21.83 mg m^{-3} throughout the culture period. It has revealed that a considerable amount of phytoplankton (natural food) exists-in Mahawewa that could be used by the fish in cages.

The % survival of the fish fed on these three feed types were not significantly different (P>0.05). However, the mean % survival of the fish fed on Feed-C (47.78±14.14) was significantly lower than the % survival of the fish fed on Feed-A (60.74 ±19.65) and Feed-B (74.56±22.49). The lack of significance among these values may be due to the high standard deviation among these respective mean values (Table 2). As fish diseases were not observed in cages throughout the culture period, fish diseases were not responsible for the lowest % survival in Feed-C. However, the highest % survival was recorded in the cages fed on ipil-ipil leaves incorporated in diet Feed-B. It was envisaged that the toxic "mimosine" in fresh ipil-ipil leaves incorporated as 10-12% in Feed-B did not affected on the % survival of fish. Zamal *et al.* (2008) also observed that ipil ipil leaf meal could be used as protein substitute up to 25% and optimum level 15% in the diet of growing tilapia recording 100% survival.

The ADG of *O. niloticus* (GIFT strain) in this trial was significantly different (P<0.05). The ADG in Feed-C (1.0761 g day^{-1}) was significantly higher than the ADG in Feed-A (0.7429 g day^{-1}) and Feed-B (0.5076 g day^{-1}). However, the ADG values of the fish fed on Feed-A & Feed-B were higher than the values cited by Coche (1982) for *O. mosambicus* extensively culture in cages that was recorded as 0.36 g day^{-1}. Perhaps the lower ADG in *O. mosambicus* may be due to the insufficient feed amount for fish, as it was extensive farming system. The highest ADG was recorded with the fish fed on Feed-C, followed by Feed-A and Feed-B. According to Castanares *et al.* (1992), low palatability and digestibility of ipil ipil leaves may be one of the reasons for low ADG of fish that fed on fresh ipil-ipil leaves incorporated diet Feed-B. As such, Hasan *et al.* (1977) and Hasan *et al.* (1990) have observed the poor performance of *Cyprinus carpio* fry and *Labeo rohita* fry fed on diets containing ipil ipil leaves due to the presence of the toxic amino acids "mimosine". Adaparusi and Agbede (2004) have observed the high fiber content in ipil ipil leaves that are affected on digestibility and it may be a reason for low ADG of the fish fed on Feed-B which is incorporated ipil ipil leaves. However, Santiago *et al.* (1988) has observed that 12.5% inclusion of ipil ipil leaves for the diets did not affect the growth, but the inclusion of ipil ipil leaves up to 25% or more adversely affected on the growth of *O. niloticus*. Accordingly, the inclusion amount of ipil ipil leaves in Feed-B (10-12%), may not have affected the growth of fish. Then the provided feed amount Feed-B may not be sufficient. Catanares *et al.* (1992) have observed the reduced weight gain of Nile tilapia while feeding with fresh ipil ipil leaves until satiation. They have suggested it may be necessary to pretreat fresh ipil ipil leaves to reduce the detrimental effect of mimosine to Nile tilapia. Inactivating the "mimosine" inhibitor through soaking fresh ipil ipil leaves in the water for 48 hrs and sundried for 12 hrs has been reported to reduce the mimosine content (Wee and Wang, 1987). This should be considered in the future research using ipil ipil leaves as an ingredient for fish feed.

The highest standard deviation of ADG was recorded in Feed-C. It may be due to the unequal growth of fish that could happen due to the use of different amounts of feed through the competition for feed. The smallest standard deviation in ADG in Feed-B, followed by Feed-A revealed that the fish fed on these 2 feeds have shown a smaller growth than the fish fed on Feed-C. It could happen due to the use of feed almost similarly without having or with a minimum competition among the fish for feed. The lack of competition may be due to the less palatability of Feed B which contains ipil ipil leaves as a part (10-12%). According to Santiago *et al.* (1988), the less palatability of the diet that incorporated fresh ipil ipil leaves is due to the presence of "mimosine", which is a toxic non-protein amino acid. Hasan *et al*. (1990) also observed the poor growth responses for Rohu (*L. rohita*) and for Carp (*C. carpio*) (Hasan *et al.*, 1997) while feeding with the diet containing ipil ipil leaves due to the presence of mimosine too. Jakson *et al.* (1982) found that leucaena (ipil ipil) leaf meal as a 25% replacement of fishmeal in a diet for tilapia supported poor growth, which was caused by the possible toxic effects of mimosine.

The lowest weight gain of the fish fed on Feed-B (fresh ipil ipil leaves incorporated diet) may be due to the presence of mimosine, which could cause certain adverse effects on growth. As such, the relatively low body fat content (Table 4) of the fish fed on Feed-B reflects the utilization of stored fat as energy source for metabolism, during the experimental period, which resulted in weight loss. Castanares *et al.* (1992) also observed the weight loses of Tilapia which fed on ipil ipil leaves incorporated feed.

However, the condition factor of the fish fed on Feed-A, Feed-B and Feed-C were not significantly different (P>0.05) and it has revealed that the well-being and health of fish fed on these 3 feed types were not different.

Protein is the most expensive component in diets for aquatic species. However, the dietary protein requirements of fish are generally higher than those of land animals (Wilson, 2002). Accordingly, the commercial feed has to be prepared to fulfill this requirement and the crude protein % (32%) is higher than two aqua-feeds. The protein percentage (%) for Feed-A was provided through local Fm and for Feed-B through local Fm and ipil ipil leaves. Accordingly, the 2 aqua-feeds used (Feed-A and Feed-B) are less expensive than the commercial feed used. The production cost for Feed-B was Rs.16 $kg^{-1}$and it is a merger amount compared with the price of Feed-C i.e. Rs.160 kg^{-1}. Accordingly, high profit should not be expected using commercial fish feed, in spite of its higher percentage (%) of protein compared to the 2 aqua-feeds. In addition, the low production cost of the latter indicates the economic viability of these 2 feeds.

The fish fed on Feed-B had the highest carcass protein content (Table 4). Adeparusi and Agbede (2004) have observed the same thing i.e. the better protein gain in *O. niloticus* body when fed on ipil ipil leaves incorporated diets. Accordingly, more % protein could be provided to the consumers through the fish fed on Feed-B than Feed-A and Feed-C. Olvera-Novoa *et al.* (1997) also observed an improvement with substitution of plant protein *i.e.* cowpea (*Vigna unguiculata)* protein concentrate in to the diet up to 20, 30, 40, and 50% resulting the highest protein carcass content in Tilapia fingerlings after 63 days fry rearing period. Then, Feed-B could be recommended for Tilapia (GIFT strain) food fish culture as it could provide more % protein to the fish flesh. Further research is necessary in this regard. It may be a chance to the traditional fish nutritionist to give up the idea of high percentage (%) of protein in the provided feed to enhance the growth performance of the fish. Due to the continuously increasing price of Fm, the use of ipil ipil leaves in fish feed (10-12%) should be considered, as it is no-cost and this plant grows very fast in temperate climatic conditions. Zamal *et al*. (2008) have observed that ipil ipil leaf meal could be used as protein substitute up to 25% and optimum level 15% in the diet of growing tilapia.

According to Wendy *et al*. (1998), the nutritional needs of the fish are met through a combination of the supplemental feed and complete nutritional feeds. De Silva and Perera (1983) also recommended the mixed feeding schedule concept i.e. the daily changes of the supplementary feed with low protein levels with complete feed for the better growth of fish. This may be due to the fact that supplementary feed typically contain lower levels of protein, vitamins, and other nutrients and are not formulated to meet all the nutritional requirements of the fish. According to Bowen (1982), the characteristic diet of adult tilapias is a mixture of algae, detritus, bacteria and in some excess macrophytes. Nevertheless, the fish in cage culture could utilize only a limited amount of these characteristic diets, as they cannot search food due to living in limiting space. However, the frequently changing water current could provide certain amount of this characteristic diet. Then, the use of complete diets (commercial feed) in food fish culture of GIFT Tilapia through cage culture (semi-intensive culture) could be considered as useless effort, as it cannot be economically viable. As such, the use of ipil ipil leaves, which are locally available and relatively inexpensive (no-cost) not only in Sri Lanka, but also in many developing countries, should be considered. Using these cheap protein sources for Tilapia food fish culture could reduce the feeding cost considerably.

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