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ANALYSIS OF NUTRIENT CONTENTS IN CONVENTIONAL AND NON-CONVENTIONAL FEED INGREDIENTS AND ITS EFFECTS ON CARP POLYCULTURE PRODUCTION

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ABSTRACT

A study on proximate composition of conventional and non-conventional fish feed ingredients was carried out involving two separate experiments. First experiment was conducted from April 2010 to September 2010 at the Protein and Enzyme Research Laboratory, Department of Biochemistry and Molecular Biology, Rajshahi University, Rajshahi with a view to determine nutrient (protein, lipid and carbohydrate) content of some feed ingredients i.e. Rice bran, wheat bran, mustard oil cake, *Azolla*, grass (*Cynodon dactylon*) and leaf of banana (*Musa acuminata*) among the feed samples, protein, lipid and carbohydrate content significantly varied from 6.18±0.13 (banana leaf) to 30.53±0.40% (oil cake), 3.06±0.09 (banana leaf) to 13.33±0.10% (oil cake) and 32.95±0.29 (oil cake) to 66.12±0.47% (wheat bran), respectively. Second experiment was conducted during the period from April 2011 to September 2011 at Alampur village of Sadar Upazila under Kushtia district, Bangladesh with a view to evaluate the fish production and economics under different conventional and non-conventional feed based carp polyculture systems. There were three replications for each treatment. In this experiment, treatment T_0 (Semi-intensive ponds fed with feeds like rice bran, wheat bran and oilcake as control) varied more significantly ($P<0.05$) for the mean values of total yield but in terms of total cost, total return, net benefit, net profit margin and CBR treatment T_1 (*Azolla* fed pond) was best. Therefore, the findings indicate that weeds (non-conventional feed items) are moderately nutritive and low cost effective diets for fish production.

Keywords: *Azolla*, nutrient content, non-conventional feed, carp polyculture, economic analysis.

INTRODUCTION

Growth, health and reproduction of fish and other aquatic animals are primarily dependent upon adequate supply of nutrient, both in terms of quantity and quality, irrespective of the culture system in which they are grown. Supplementary feeding plays an important role in achieving higher fish production. Conventional supplementary feed for carps comprises various bran and oil cakes. Although rice bran and mustard oil cake are being used as fish supplementary feed in Bangladesh, supply of these materials is scarce and costly. Commercial formulated fish feeds are not easily available and unaffordable to fish farmers in Bangladesh it was thus considered necessary to look for cheaper and locally available materials as substitutes. Aquatic macrophytes have been known to have potential food value (Edwards, 1980). Aquatic weeds have been utilized as food components and thus have played an important role in culture of herbivorous fish since 4000 years ago in Egypt and 2500 years ago in the Orient, including Indian subcontinent (Bardach *et al.*, 1972). The weed based system refers to the use of some inputs from plant sources, e.g., weeds or grasses or leaves or macrophytes like duck weeds, *Azolla* etc. as supplemental feed in fish production. These inputs are consumed first as feed by herbivorous fish and subsequently a part of the semi digested faecal matter of the macrophyte feeding fishes are consumed by the other fishes and plankton the remaining part will be recycled in food chain as nutrients for primary production, thus they have potentiality to increase the total fish production of aquaculture system. Duck weeds might be having as much potential as fish foods that could be utilized in preparation of suitable fish feed essential in expansion of low-cost aquaculture system in the tropics

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(Hassan and Edwards, 1992). Since long *Azolla pinnata* utilized as biofertilizer in agriculture has been popular among farmers. Now a days, its utility in pisciculture has come into limelight and has been proven worthy of note because of its two unique activities: capable of nitrogen fixation from atmosphere that enhances nitrogen in semi-intensive pisciculture systems (Ayyappan *et al.*, 1993) and used as direct food by some macrophagous fish (Cassani, 1981; Antoine *et al.*, 1987). Fresh duck weed (and also the dried meal) is suited to intensive production of herbivorous fish (Gaiger *et al.*, 1984) and duck weed is converted efficiently to live weight gain by carp and tilapia (Van Dyke and Sutton, 1977; Hepher and Pruginin, 1979; Robinette *et al.*, 1980; Hassan and Edwards, 1992; Skillicorn *et al.*, 1993).
The concept of polyculture of fish is based on the concept of total utilization of different trophic and spatial niches of a pond in order to obtain maximum fish production per unit area. Different compatible species of fish of different trophic and spatial niches are raised together in the same pond to utilize all sorts of natural food available in the pond (Rahman *et al.*, 1992). In south Asia, especially in Bangladesh, several culture combinations of indigenous and exotic carp species are commonly practiced (Miah *et al.*, 1997; Wahab *et al.*, 1994). The idea of polyculture is based on the principle that each species stocked has its own feeding niche that does not completely overlap with the feeding niches of other species. Therefore, a more complete use is made of the food resources and space available in polyculture than in monoculture. In somecases, one species enhances the food availability for other species and thus increases the total fish yield per unit area (Hepher *et al.*, 1989; Miah *et al.*, 1993; Azad *et al.*, 2004). It is true that feed expenditure is about 60%-80% of total fish production cost.
To decrease the production cost it is essential to minimize the cost for fish feed (DOF, 2010). Most of the fish farmers of Bangladesh are resource poor. They need suitable low cost aquaculture technology to set up fish farming. Weed based aquaculture system can easily minimize this issue. Comparative study of the different aquaculture system based on weeds and supplementary feeds (for semi-intensive culture) was not done in terms of growth performance, economics of the weed based system was not explored well, sufficient number of fish species was not introduced in carp-polyculture system yet and application of different weeds were not clear while comparing using conventional and non-conventional feed items and its effects on carp polyculture production. Therefore, the objectives of this study is to compare the protein, lipid and carbohydrates contents in conventional and non-conventional feed items (rice bran, wheat bran, oilcake, *Azolla*, grass and banana leaves) and to recommend suitable cost efficient feed ingredients for better fish production in carp polyculture ponds.

MATERIALS AND METHODS

First experiment was conducted for a period of six months from September 2009 to February 2010. Feed ingredients were collected from a fish farming site located at Alampur village under Kushtia district of Bangladesh. Nutrient analysis of collected samples was done at the Protein and Enzyme Research Laboratory under the Department of Bio-Chemistry and Molecular Biology, Rajshahi University, Rajshahi. The current experiment was carried out in six treatments each with three replications. For the estimation of protein (%), lipid (%) and carbohydrate (%) the treatments were assigned as T_1, T_2, T_3, T_4, T_5 and T_6 for in rice bran, wheat bran, mustard oilcake, *Azolla*, grass and banana leaves, respectively. Total protein, lipid and carbohydrate contents of the samples were determined by the micro-kjeldahl method (Rangama, 1979), Bligh and Dyer (1989) method and Anthrone method, respectively on dry weight basis.
Later experiment was conducted for a period of six months (April 2011 to September 2011) at Alampur village of Sadar Upazila under Kushtia district, Bangladesh. The experiment consisted of four treatments (T_0, T_1, T_2 and T_3) each with three replications. The treatment assignment was as T_0: Semi-intensive ponds fed with feed ingredients like rice bran, wheat bran and oilcake (control), T_1: *Azolla* fed ponds. T_2: Grass (*Cynodon dactylon*) fed ponds and T_3: Banana (*Musa acuminata*) leaf fed ponds. Liming was done at a rate of 250 kg/ha before 7 days of fertilization. All the ponds were fertilized with cow dung (1500 kg/ha), urea (40 kg/ha) and Triple Super Phosphate (TSP) (20 kg/ha) as basal dose.

Azolla was collected from the nearby research area and one tenth area of the research pond was used as *Azolla* bank. Banana leaf and grass were collected locally and chopped into very small pieces during application. Fish were stocked in all ponds after five days of basal fertilization. All the ponds were stocked with seven carp species of fishes (mean initial weight of silver carp, catla, rui, mrigal, common carp, grass carp and Thai punti were 62, 64, 57, 54, 63, 65 and 25 g respectively).

In treatment T_0, commonly available ingredients such as rice bran (30%), wheat bran (30%) and oilcake (40%) were used as supplementary feed daily at the rate of 3% of body weight of total fish. Fish were fed twice a day between 09:00-10:00 hours and between 03:00-04:00 hours with 50% of the ration allocated at each time. *Azolla* (100%), grass (100%) and banana leaves (100%) were periodically supplied in treatment T_1, T_2, and T_3 respectively as supplementary feed daily at the rate of 100% of the body weight of herbivorous fishes (*C. idella* and *P. gonionotus*) and made available 24 hours per day. After stocking of the fish species all ponds were fertilized weekly with urea 25 kg/ha and TSP 12.5 kg/ha respectively.

Fish production (kg/ha/6months) = Fish biomass at harvesting – Fish biomass at stocking

Cost-Benefit Analysis:

Net benefit (Tk.) = total return (sale) – total cost (investment)

$$\text{Net profit margin (\%)} = \frac{\text{Net benefit}}{\text{Total investment}} \times 100$$

$$\text{CBR} = \frac{\text{Net benefit}}{\text{Total investment}}$$

Statistical analysis

All the data were subjected to ANOVA (analysis of Variance) using computer software SPSS (Statistical Package of Social Science). The mean values were also compared to see the significant difference from the DMRT (Duncan Multiple range Test) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Nutrient analysis

In first experiment, the variations in the mean values of nutrient contents (protein, lipid and carbohydrate) in different food items are presented in Table 1.

Table 1. Variations in the protein, lipid and carbohydrate contents of different fish feed ingredients (On dry weight basis)

Treatments	Nutrient content (%)		
	Protein	Lipid	Carbohydrate
T_1 (Rice bran)	14.40 ± 0.32^d	10.41 ± 0.31^b	44.09 ± 0.67^e
T_2 (Wheat bran)	17.13 ± 0.07^c	6.69 ± 0.30^c	66.12 ± 0.47^a
T_3 (Oil cake)	30.53 ± 0.40^a	13.33 ± 0.10^a	32.95 ± 0.29^f
T_4 (*Azolla pinnata*)	18.58 ± 0.09^b	3.19 ± 0.10^d	50.21 ± 0.54^b
T_5 (Grass- *Cynodon dactylon*)	7.26 ± 0.18^e	6.31 ± 0.13^c	46.36 ± 0.16^d
T_6 (Banana leaf –*Musa acuminata*)	6.18 ± 0.13^f	3.06 ± 0.09^d	48.50 ± 0.51^c
F value	16.42	13.88	114.85
P value	0.002	0.004	0.0000008

Figures bearing common letter(s) in a column as superscript do not differ significantly ($P < 0.05$)

In the present study the protein content significantly varied from 6.18±0.13 in T_6 (banana leaf) to 30.53±0.40% in T_3 (mustard oilcake). Lipid content significantly varied from 3.06±0.09 in T_6 (banana leaf) to 13.33±0.10% in T_3 (mustard oilcake). Carbohydrate significantly varied from 32.95±0.29 in T_3 (mustard oilcake) to 66.12±0.47% in T_2 (wheat bran). The highest protein and lipid content was found in treatment T_3 (mustard oilcake) whereas the highest carbohydrate content was found in treatment T_2, wheat bran (66.12±0.47%) followed by T_4, *Azolla* (50.21±0.54%), T_6, banana leaf (48.50±0.51%), T_5, grass (46.36±0.16%), T_1, rice bran (44.09±0.67%), T_3, mustard oilcake (32.95±0.29%). Hepher (1989) reported the protein content of ricebran, wheat bran, oil cake and *Azolla* as 11.88%, 14.57%, 30-33% and 19.27%, respectively that is more or less similar to the findings of the present study. The chemical composition of *Azolla* species varies with ecotypes and with the ecological conditions and the phase of growth. The crude protein content is about 19-30 percent dry matter basis during the optimum conditions for growth (Peters *et al.*, 1979; Becking, 1979). The protein contents of *Azolla* species are comparable to or higher than that of most other aquatic macrophytes. Aquatic weeds' are highly nutritious with protein content of 20-30%, when cultivated in nutrient rich waters (Culley *et al.*, 1981). Importantly, they are prefered food of a wide range of herbivorous fish such as grass carp (*Ctenopharyngodon idella*), silver barb (*Puntius gonionotus*, *Puntius jerdoni*), tilapias (*Oreochromis niloticus*, *Tilapia rendalli*, *Tilapia zillii*) and rohu (*Labeo rohita*) (Singh *et al.*, 1967; Gaiger *et al.*, 1984). Kalita (2006) reported that feeding herbivorous fish with duckweed is preferable because of their low content of fibre and fat. Throughout the world, increasing attention has been given on organic foodstuffs including fish. European Union (EU) directives suggest that fish captured or harvested from the wild cannot be labeled as "organic". It should be produced in under specific conditions (Alderman and Hasitings, 1998). The organic fish farming is a holistic management system, which promotes and enhances agro-ecosystem health including biodiversity, biological cycle and soil biological activity (Bjorklund *et al.*, 1990). Organic production systems are based on specific and precise standard of production, which aim at achieving optimal agro-ecosystem, and which are socially, ecologically and economically sustainable. Mustard oil cake, the source of protein in the conventional fish feed, contained, 38.6% crude protein. *Azolla* showed high percentage of protein (23.4%) and therefore can be considered fairly nutritive. Being an omnivore, the fish can also feed on vegetation (Santhanam *et al.*, 1990) and may be able to assimilate *Azolla* in the diets.

Fish production

In second experiment, significant difference was found among the treatments for the mean values of fish production of all the species (Table 2).

Table 2. Variations in the production (kg/ha/6 months) of carp fishes under different feeding regime

Treatments	Fish production (kg/ha/6 months)
T_0(WB, RB, OC)	4403.51±0.88^a
T_1(*Azolla*)	3675.33±0.58^b
T_2(Grass)	2593.67±0.11^c
T_3(Banana leaf)	2541.00±0.67^d
F value	52.34
P value	0.0004

Figures bearing common letter(s) in a row as superscript do not differ significantly (P <0.05)

The lowest total yield (Kg/ha/6 months) was found as 2541.00±0.67 (T_3) whereas the highest total yield was 4403.51±0.88 (T_0) for all the species because in treatment T_0, expensive formulated feed was applied. Significant difference was found among the treatments. Roy *et al.* (2003) obtained total yield as 2560 kg/ha/7 months in carp polyculture system which was closer to the present study. Azim and Wahab (2003) also recorded total yield 2020 kg/ha/4 months in duckweed base system. Majhi *et al.* (2006) worked on effect of *Azolla* feeding on growth performance of grass carp and obtained total production is 185.76 kg/1000m^2 in 150 days culture period. So, the findings of the present study more or less in agreement with previous research works.

Cost-Benefit Analysis

Economic viability is an important criterion for sustainability of any system. Shang (1981) emphasized the importance of economic analysis, as it provides a basis not only for the decision making of the individual fish farmer, but also for the formulation of aquaculture policies. The economics of fish farming under different treatments (experiment-2) are presented in Table 3.

Table 3. Economics of fish farming under different treatments

Parameters \ Treatments	T_0 (RB, WB, Oil cake)	T_1 (*Azolla*)	T_2 (Grass)	T_3 (Banana leaf)	F value	P value
Lease value (Tk.)	40000.0±0.00^a (16.95%)	40000.0±0.00^a (32.41%)	40000.0±0.00^a (32.41%)	40000.0±0.00^a (32.41%)	-	-
Pond preparation (Tk.)	10550.0±0.00^a (4.47%)	10550.0±0.00^a (8.55%)	10550.0±0.00^a (8.55%)	10550.0±0.00^a (8.55%)	-	-
Fertilizer (Tk.)	25400.0±0.00^a (10.77%)	25400.0±0.00^a (20.58%)	25400.0±0.00^a (20.58%)	25400.0±0.00^a (20.58%)	-	-
Fish seed (Tk.)	32480.50±0.0^a (13.77%)	32480.50±0.0^a (26.31%)	32480.50±0.0^a (26.31%)	32480.50±0.0^a (26.31%)	-	-
Feed (Tk.)	112500.0±0.0^a (47.68%)	0.00±0.00^b (0.00%)	0.00±0.00^b (0.00%)	0.00±0.00^b (0.00%)	250.15	0.00
Harvesting cost (Tk.)	15000.0±0.00^a (6.36%)	15000.00±0.0^a (12.15%)	15000.00±0.0^a (12.15%)	15000.00±0.0^a (12.15%)	-	-
Total cost (Tk.)	**235930.5±.00^a**	**123430.5±0.0^b**	**123430.5±0.0^b**	**123430.5±0.0^b**	**29.04**	**0.002**
Total return (Tk.)	418376.85 ±5125.59^a	330175.35 ±2155.32^b	239526.95 ±2335.84^c	235068.40 ±1965.31^c	49.51	0.0004
Net benefit (Tk.)	182446.35 ±3265.00^b	206744.85 ±3221.73^a	116096.45 ±3554.84^c	111639.90 ±2056.87^c	41.84	0.0006
Net profit margin (%)	77.21±2.40^b	167.20±18.77^a	94.38±2.91^{ab}	90.25±1.73^{ab}	26.57	0.002
CBR	0.77±0.02^b	1.67±0.18^a	0.94±0.03^{ab}	0.90±0.02^{ab}	6.21	0.05

Figures bearing common letter(s) in a row as superscript do not differ significantly ($P < 0.05$) % of total cost in parentheses (Values in the parenthesis indicates % of total cost)

Total cost significantly varied from 123430.50±0.00 Tk/ha/6 months (T_1, T_2, T_3) to 235930.50±0.00 Tk/ha/6 months (T_0). Total return significantly varied from 235068.40±1965.31Tk/ha/6 months (T_3) to 418376.85±5125.59 Tk/ha/6 months (T_0). Net benefit significantly varied from 111639.90±2056.87 Tk/ha/6 months (T_3) to 206744.85±3221.73 Tk/ha/6 months (T_1). The Net profit margin (%) significantly varied from 77.21±2.40 (T_0) to 167.20±18.77% (T_1). The CBR significantly varied from 0.77±0.02 (T_0) to 1.67±0.18 (T_1). Data on economics indicated that the treatment T_1 (*Azolla* fed pond) was more profitable than that of others. Total cost was higher in Treatment T_0 (Semi-intensive) might be due to the feed cost (47.68% of total cost) whereas in other treatment there was very negligible or no feed cost (0% of total cost). Shanmugasundaram and Balusamy (1993) stated that benefit cost ratio was 1.88 which was similar to the present study. Miah *et al.* (1997) also mentioned BCR (Benefit Cost Ratio) value of 1.22 which was lower than the findings of the present study was due to high initial biomass of all the species and also the higher survival rate.

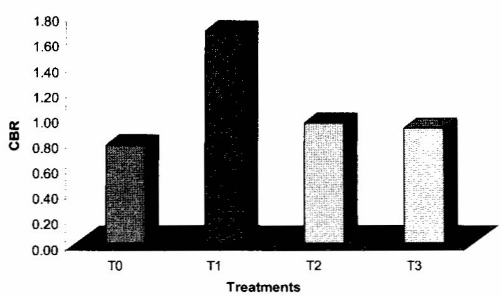

Fig. 3. Variation in the mean values of CBR under different treatments

In the present study protein, protein content varied from 6.18 to 18.58% in weeds and 14.40 to 30.53% in commonly available fish feed ingredients. Rice bran, wheat bran and mustard oilcake are being used as supplementary feed in Bangladesh. But these ingredients are costly. Although present findings indicate that non-conventional feed ingredients are moderately nutritive and cost effective diets for fish. The results showed that the introduction of fish edible floating macrophyte *i.e.*, *Azolla* help to maintain the aquatic environment for sustainable aquaculture. Considering the nutritive value, production and economics it can be concluded that *Azolla* (non-conventional feed item) based carp polyculture can potentially be used for poor fish farmer.Therefore, based on the current study, it is recommended to conduct further study for optimizing the stocking density of carps in *Azolla* based carp polyculture.

REFERENCES

Alderman, D. and Hastings, T. 1998. Antibiotic use in aquaculture: development of antibiotic resistance potential for consumer health risks. *Int.J. Food Sci. and Tech.*, 33: 139-155.

Antoine, T., Wery, P., Micha, J.C. and Van H.C. 1987. Comparison of the growth and chemical composition of *Oreochromis(Tilapia) niloticus* and *Cichlasoma(Theraps) melanurum* fed with Azolla. *Aquaculture,* 66:181-196 (in French).

Ayyappan, S., Dash, B., Pani, K.C. and Tripathi, S.D. 1993. Azolla – a new aquaculture input, *National meet on Aquafarming system practices and potential,* Abstract No. *OFS-2*, 10-11 February, 1993, CIFA, Bhubaneswar, India.

Azad, M.A.K., Rahman, M.R., Rahman, Z., Kader, M.A., Haque M.M. and Alam, M.J. 2004. Polyculture of carp, tilapia and pangas using low cost inputs. *Pak. J. Biol. Sci.*, 7(11): 1918-1926.

Azim, M.E. and Wahab, M.A. 2003. Development of a duckweed-fed carp polyculture system in Bangladesh. *Aquaculture,* 18(1-4):425-438.

Bardach, J.E., Ryther, J.H. and Melarney, W.O. 1972. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms, Wiley-Interscience, New York.

Becking, J.H. 1979. Environmental requirements of *Azolla* for use in tropical rice production. pp. 345-373. In: Nitrogen and Rice, Los Banos, Laguna, International Rice Research Institute.

Bjorklund, H., Bondestam, J. and Byland, G. 1990. Residue of oxytetracycline in wild fish and sediments from fish farm. *Aquaculture*, 86: 359-367.

Bligh, E.G. and Dyer, W. 1989. Total Lipid Extraction and Purification., *Canadian. J. Biochem. Physiol,*37:911.

Cassani, J.R. 1981. Feeding behaviour of underyearling hybrids of grass carp, *Ctenopharyngodon idella* and the bighead carp, *Hypophthalmichthys nobilis* on selected species of aquatic plants. *J. Fish Biol.*, 18:127-133.

Culley, D.D., Rejmankova, E., Koet. J. and Prye. J.B. 1981. Production, chemical quality and use of duckweeds (Lemnaceae) in aquaculture, waste management and animal feeds. *J. World Maricult. Soc.*, 12: 27-49.

DOF, 2010. Department of Fisheries, Ministry of Fisheries and Livestock, Government of Bangladesh, pp. 102-104.

Edwards, P. 1980. Food potential of aquatic macrophytes. *ICLARM Studies and Reviews,* 5: 51, ICLARM Manila.

Gaiger, I.G., Porath, D. and Granoth, G. 1984. Evaluation of duckweed (*Lemna gibba*) as feed for tilapia *(Oreochromis nilotieus* cross *Oreochromis aureus*) in a recirculating unit. *Aquacultre*, 41: 235-244.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research.John Wiley & Sons. New York, 2: 304-307.

Hassan, M.S. and Edwards, P. 1992, Evaluation of duck weed (*Lemnaperpusilla and Spirodela polyrhiza*) as feed for Nile Tilapia (*Oreochromis niloticus*). *Aquaculture*, 104: 315-326.

Hepher B., Milstein A., Leventer H. and Teltsch B. 1989. The effect of fish density and species combination on growth and utilization of natural food in ponds. *Aquac. Fish. Manage.* 20: 59-71.

Hepher, B. and Pruginin, Y. 1979. Guide to fish culture in Israel. Fertilization, manuring and feeding. Foreign Training Dept., Israel, 4:61.

Kalita, P. 2006. Evaluation of nutritional potential of some aquatic weeds of north-east India for formulation of fish feed for Indian major carps. Ph. D. Thesis, Tezpur University, Tezpur, Assam, India.

Majhi S.K., Das A. and Mandal, B.K. 2006. Growth Performance and Production of Organically Cultured Grass Carp *Ctenopharyngodon idella* (Val.) Under Mid-Hill Conditions of Meghalaya; North Eastern India. *Turkish J. Fisheries and Aquatic Sci.,* 6: 105-108.

Miah, M.S., Uddin, M.S. and Shah, M.S. 1993. Effects of artificial feed in carpspolyculture system. *Bangladesh J. Agric. Sci.,* 20: 359-364.

Miah, M.S., Uddin, M.S. and Shah M.S. 1997. Effect of stocking ratios on the growth and production of fishes in mixed polyculture system. *Bangladesh J. Fisheries.*, 20:135-138.

Peters, G.A., Mayne, B.C., Ray, T.B. and Toia, R.E. 1979. Physiology and biochemistry of the *Azolla-Anabaena* symbiosis. pp. 325-344. In: Nitrogen and Rice. Los Baños, Laguna, Phillipines, International Rice Research Institute.

Rahman M.M., Varga, I. and Chowdhury S.N. 1992. Manual on polyculture and integrated fish farming in Bangladesh. Project report of BGD/87/045/91/11, Food and Agriculture Organization (FAO), Rome, Italy.

Rangama, S. 1979. Manual of analysis of Fruits and vegetable products, Tata McGraw- Hill Publishing Company Ltd. New Delhi.

Robinette, H.R., Brunson, M.W. and Day, E.J. 1980. Use of duck weed in diets of channel catfish. Proc. 13th Ann. Conf. SE Assoc. Fish Wildlife Age, 108-114 pp.

Roy, N.C., Wahab, M.A., Khatoon, H. and Thisted, S.H. 2003. Economics of Carp-SIS polyculture in rural farmer's pond. *Pakistan J. Biol. Sci.*, 6(1): 61.64.

Santhanam, R., Sukumaran, N. and Natarajan, P. 1990. A Manual of Fresh Water Aquaculture. Oxford and IBH Publishing Go. Pvt. Ltd., New Delhi, 193 pp.

Shang, Y.C. 1981. Aquaculture Economics: Basic concept and methods of analysis. Westview Press. Boulder, Colorado.

Shanmugasundaram, V.S and Balusamy, M. 1993. Rice-fish-azolla: a sustainable farming system. *NAGA, The ICLARM Quarterly*, 16(2-3): 23.

Singh, S.B., Pillai, K.K. and Chakraborty, P.C. 1967. Observation on the efficacy of grass carp in controlling and utilizing aquatic weeds in ponds in India. *Proc. Indo-Pacific Fish Counc.*, 12(2): 220-235.

Skillicorn, P., Spira, W. and Journey, W. 1993. Duckweed Aquaculture- A New Aqutic Farming System for Developing Countries. The World Bank 76pp. Washington DC.

Van-Dyke, J.M. and Sutton, D.L. 1977. Digestion of duck weed (*Lemna spp*) by the grass carp (*Ctenopharyngodon idella*). *J. Fish Biol.*,11: 273-278.

Wahab, M.A., Ahmed, Z.F., Haq, M.S. and Begum, M. 1994. Compatibility of silver carp in the polyculture of cyprinid fishes. *Prog. Agric.*, 5(2): 221-227.