Aquatic Weed as Potential Feed for Mozambique tilapia, *Oreochromis mossambicus*

Mukti Pada Bag\(^*\), Subhash Chandra Mahapatra\(^1\) and Pavuluri Srinivasa Rao\(^2\)

\(^1\)Rural Development Centre, Indian Institute of Technology, Kharagpur, West Bengal, India  
\(^2\)Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India

**Abstract**

A study was conducted to evaluate the nutritional potentials of three commonly available aquatic weeds namely, lemma (*Lemna minor*), water hyacinth (*Eichhornia crassipes*) and azolla (*Azolla pinnata*) for ascertaining their suitability in fish feed with the aim of reducing the cost of traditional feeds. Three isonitrogenous (30% crude protein approximately) and isocaloric (4.0 kcal g\(^{-1}\) approximately) diets were formulated including lemma, water hyacinth and azolla as principal ingredient. Three groups of juvenile tilapia fish (*Oreochromis mossambicus*) of thirty (30) number per group (Average weight 5.1 ± 0.15 g; length 4.5 ± 0.12 cm) were fed with three different types of feeds with lemma meal (LNM), water hyacinth meal (WHM) and azolla meal (AZM) for 90 days duration. Body weight gain, feed conversion ratio (FCR), protein efficiency ratio (PER) and gonadosomatic index (GSI) were significantly (P<0.05) high in LNM fed fish in comparison to the others. The lemma possibly contains superior quality of protein which in turn influenced growth, growth parameters and fecundity of cultured fish.

**Keywords:** Lemma; Isonitrogenous; Tilapia fish; Feed conversion ratio

**Introduction**

Fish feed generally constitutes 60-70% of the operational cost in intensive and semi-intensive aquaculture system [1]. The fish feed used in aquaculture is quite expensive, irregular and short in supply in many third world countries. These feeds are sometimes adulterated, contaminated with pathogen as well as containing harmful chemicals for human health. Naturally there is a need for the development of healthy, hygienic fish feed which influences positively the growth and quality of the cultured fish.

Considering the importance of nutritionally balanced and cost-effective alternative diets for fish, there is a need for research effort to evaluate the nutritive value of different non-conventional feed resources, including terrestrial and aquatic macrophytes [2-5]. Aquatic and terrestrial macrophytes have been used as supplementary feeds in fish farming since the early times of freshwater fish culture [6] and still play an important role as fish feed in extensive culture systems [7]. The aquatic weeds have been shown to contain substantial amounts of protein and minerals [8]. Valente et al. [9] reported clearly that macro algae such as *G. bursapastoris, U. rigida* and *G. cornea* have great potential as alternative ingredients in diets for European sea bass and to make aquaculture a viable and attractive venture. Mukherjee et al. [11] reinforced the utilisation of some aquatic weeds as promising sources of nutraceuticals in fish-feed.

Keeping the above in view, the main objective of the present study is to formulate feed incorporating the weeds as key ingredient and the effect of formulated feeds on yield and growth performances of Mozambique tilapia (*Oreochromis mossambicus*).

**Material and Methods**

**Experimental set up**

Thirty fingerlings in triplicate groups used in three different treatments. Altogether they are two hundred and seventy (270) in number. Nine groups of tilapia fingerlings comprising fifty (50) individuals each (average weight 5.0–5.5 g and length 4.0-4.5 cm) were obtained from Balarampur fish farm, 3 Km away from IIT-Kharagpur, West Bengal, India. The fish fingerlings were treated with potassium permanganate solution (1 mg L\(^{-1}\)) to remove any external parasites and were acclimatized in a tank for two days. Each group of fingerlings also were initially weighed to record the initial biomass. They were stocked in 9 rectangular cemented tanks (1000 L) and three different feeds were administered. The water system was static in nature and the bottom of the tank was filled with local agricultural inert soil (pH 6.6 ± 0.05). The experiment was conducted for 90 days. Declorinated well water (temperature 30 ± 4°C, pH 7.0 ± 0.05, free CO\(_2\) 0.6 ± 0.01 mg L\(^{-1}\),

| Ingredient (%) | Lemna | Water hyacinth | Azolla |
|----------------|-------|----------------|-------|
| Dry matter     | 92.81 ± 1.50 | 92.68 ± 1.58 | 92.56 ± 1.52 |
| Organic matter | 82.92 ± 1.30 | 82.20 ± 1.40 | 82.80 ± 1.30 |
| Crude protein  | 24.24 ± 0.50 | 19.70 ± 0.52 | 20.56 ± 0.54 |
| Crude lipid    | 9.07 ± 0.09  | 7.98 ± 0.10  | 9.89 ± 0.09  |
| Ash            | 9.89 ± 0.06  | 10.48 ± 0.07 | 9.76 ± 0.08  |
| Nitrogen free extract | 9.81 ± 0.05 | 36.81 ± 0.04 | 31.42 ± 0.06 |
| Crude fibre    | 9.58 ± 0.03  | 9.58 ± 0.04  | 9.24 ± 0.04  |
| Gross energy (Kcal g\(^{-1}\)) | 3.74 ± 0.02 | 3.70 ± 0.03 | 3.69 ± 0.04 |

**Table 1:** Biochemical composition (mean ± SD) of lemma, water hyacinth and azolla used for feed for tilapia (*O. mossambicus*).
Nitrogen-free extract was determined by subtracting the total ash from DM. Crude fibre was determined using a moisture free defatted sample which was digested by a weak acid HCl (0.1N) followed by petroleum ether by Soxhlet method; total ash by igniting at 550°C for 3 h in muffle furnace. Organic matter (OM) was calculated by subtracting available nitrogen 0.5 ± 0.05 mg L⁻¹ and dissolved oxygen (6.0 mg L⁻¹) was used in the experiment.

**Feeding**

The feed was offered twice a day, in a submerged feeding tray at 09.30 am and 4.30 pm on everyday for 1 h in each tank. Unconsumed feed was removed at 6.00 pm and dried in a hot air oven at 100°C. Feed consumption was estimated by subtracting the weight of the unconsumed feed from the weight of the feed offered. Fish, feed samples, and unconsumed feeds were weighed on an electric balance to an accuracy of 0.1 mg.

**Growth calculation**

Growth and nutrient utilization were determined in terms of feed intake (FI), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), energy retention (ER) and hepatosomatic index (HSI) as follows (Bag et al., 2011) [12]:

\[
FI \left( \text{g fish}^{-1} \text{day}^{-1} \right) = \text{Total feed intake per fish/number of days}
\]

\[
\text{SGR} \left( \% \text{day}^{-1} \right) = 100 \times \frac{\ln[\text{final body weight}] - \ln[\text{initial body weight}]}{\text{no. of Days}}
\]

\[
\text{FCR} = \frac{\text{Feed intake}}{\text{Live weight gain}}
\]

\[
\text{PER} = \frac{\text{Live weight gain}}{\text{Crude protein intake}}
\]

\[
\text{HSI} \left( \% \right) = \frac{\text{Liver weight}}{\text{Total body weight}} \times 100
\]

\[
\text{GSI} \left( \% \right) = \frac{\text{Weight of gonad}}{\text{Total body weight}} \times 100
\]

**Analysis**

Feeds and carcass samples were analyzed following standard procedures (AOAC, 1990) [13]: Dry matter (DM) after drying in a hot air oven at 105°C for 24 h; crude protein (CP) by Kjeldahl method (N×6.25) after acid hydrolysis, crude lipid (CL) after extraction with petroleum ether by Soxhlet method; total ash by igniting at 550°C for 3 h in muffle furnace. Organic matter (OM) was calculated by subtracting total ash from DM. Crude fibre was determined using a moisture free defatted sample which was digested by a weak acid HCl (0.1N) followed by a weak base NaOH (0.1N) using the Fibertec System 2021 (FOSS, Denmark). Nitrogen-free extract was determined by subtracting the sum of crude protein, crude lipid, crude fibre and ash from DM. Gross energy was determined using a Bomb Calorimeter Model-DFU 24by combusting sample in a chamber pressurized with pure oxygen and resulting heat measured by increase in the temperature of the water surrounding the bomb.

**Statistical analysis**

Data are presented as means ± SD. One-way ANOVA was used to find out the significant effects of feed on growth and growth parameters [14]. Duncan’s new multiple range tests were also done to determine the differences of the results were significant or not [15].

**Results and Discussion**

The principal feed ingredients were collected from local pond at very low cost. These substances was economically cheap but contained significant amount of crude protein (above 20%). Biochemical composition of lemna, water hyacinth and azolla used in feed for tilapia are shown in table 1. Diets used for growth trial were prepared that feed formulations remain almost isonitrogenous (30 g 100 g⁻¹) and isoenergetic (4Kcal g⁻¹) in nature. Diet formulations are presented in table 2. Mustard oil cake, wheat flour, rice bran, egg shell dust and vitamin premix were common ingredient in every feed tested. These ingredients were used to compensate lipid, protein and calcium deficiency in formulated feed. Wheat flour was selected as binder. Each feed was fortified with egg shell dust which is available free of cost for calcium supplement. This was added keeping in mind that the developing fish needs huge quantity of calcium for its bone development. The different ingredients were thoroughly mixed using a food mixer (A200 Hobart Ltd). The proportion of different feed ingredients was determined by using Pearson’s square method. The mixture was given the shape of pellets using a Pellet Mill (Model CL2) with a 12 mm die specification. The resulting pellets were dried under sun and then packed in polythene bags and kept in dry and cool place at 30°C.

The highest weight gain (83.33 g) was observed in the LNM applied feed series followed by WHM (64.66 g) and AZM (60.66 g) (Figure 1) applied feed series. The length of fish was maximum (12.9cm) in LNM fed treatment and minimum (10.9cm) in AZM fed treatment. The

---

**Table 2:** Formulation and composition of the experimental diets (%).

| Sl. no | Name of feed | Ingredients | % of ingredient in formulated feed | % of crude protein | % of lipid | % of carbohydrate | * Calorific value of feed (kcal/g) |
|-------|--------------|-------------|-----------------------------------|-------------------|------------|------------------|---------------------------------|
| 1     | LNM          | Lemna dust  | 10                                 | 30.10 ± 0.5       | 9.2 ± 0.05 | 11.2 ± 0.07      | 4.1 ± 0.05                      |
|       |              | Rice bran   | 34                                 |                   |            |                  |                                 |
|       |              | MOC         | 10                                 |                   |            |                  |                                 |
|       |              | Wheat flour | 01                                 |                   |            |                  |                                 |
|       |              | Egg shell dust and vitamin premix (3:1) | 46 | | | |
| 2     | WHM          | Water hyacinth dust | 10 | 29.70 ± 0.60 | 9.0 ± 0.05 | 12.3 ± 0.06 | 4.0 ± 0.03 |
|       |              | Rice bran   | 32                                 |                   |            |                  |                                 |
|       |              | MOC         | 10                                 |                   |            |                  |                                 |
|       |              | Wheat flour | 01                                 |                   |            |                  |                                 |
|       |              | Egg shell dust and vitamin premix (3:1) | 47 | | | |
| 3     | AZM          | Azolla dust | 10                                 | 30.56 ± 0.60      | 9.1 ± 0.06 | 12.7 ± 0.05      | 4.1 ± 0.04                      |
|       |              | Rice bran   | 31                                 |                   |            |                  |                                 |
|       |              | MOC         | 10                                 |                   |            |                  |                                 |
|       |              | Wheat flour | 01                                 |                   |            |                  |                                 |
|       |              | Egg shell dust and vitamin premix (3:1) | 48 | | | |

*Carbohydrates calculated by difference

---

Statistical analysis

Data are presented as means ± SD. One-way ANOVA was used to find out the significant effects of feed on growth and growth parameters [14]. Duncan’s new multiple range tests were also done to determine the differences of the results were significant or not [15].
The feed prepared with lemna as principal source of protein enhanced growth significantly and thereby yield of Mozambique tilapia, *Oreochromis mossambicus*. Such improved quality of fish would claim higher economic return to the tilapia fish farmers. Use of locally available feed ingredient like lemna would reduce the cost of formulated feed and preparation of feed may be done at small scale level leading to employment generation in rural areas.

**Conclusion**

The feed prepared with lemna as principal source of protein was significantly higher in LNM fed fish than WHM and AZM feed treatment indicating the better quality of protein in the feed produced from lemna (LNM). Kalita et al. [5] reported aquatic weeds such as *L. reptans* and *L. minor* could be important sources of proteins, vitamins and minerals, suitable for incorporation in fish diet. Though anti-nutritional factors were found to be present in these weeds, their levels were within tolerable limits and consumption of these plants would not result in any deleterious effect on the growth of fish.

The higher value of GSI indicates that the LNM has better impact on the reproductive function. The meal prepared from azolla has the lowest impact on reproductive function when compared to with other two meals. The mortality of fish was significantly (P<0.05) lower in LNM administered series than other two meals reflecting a better acceptance of the feed among the fish from beginning of the feed administration.

**References**

1. Singh PK, Gaur SR, Chari MS (2006) Growth Performance of *Labeo rohita* (Ham.) Fed on Diet Containing Different Levels of Slaughter House Waste. *Journal of Fisheries and Aquatic Science* 1: 10-16.

2. Edwards P, Kamal M, Wee KL (1985) Incorporation of composted and dried water hyacinth in pelleted feed for the tilapia, *Oreochromis niloticus* (Peters). *Aquaculture Research* 16: 233-248.

3. Wee KL, Wang SS (1987) Nutritive value of *Leucaena* leaf meal in pelleted feed for Nile tilapia. *Aquaculture* 62: 97-108.

4. Mondal TK, Ray AK (1999) The nutritive value of *Acacia auriculiformis* leaf meal in compounded diets for *Labeo rohita* fingerlings. The Fourth Indian Fisheries Forum Proceedings: 295-298.

5. Kalita P, Mukhopadhyay PK, Mukherjee AK (2007) Evaluation of the nutritional quality of four unexplored aquatic weeds from North East India for the formulation of cost-effective fish feeds. *Food Chem* 103: 204-209.

6. Bardach JE, Ryther JH, McAlarney WO (1972) Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. *Wiley-Interscience*, New York, USA.

7. Edwards P (1987) Use of terrestrial and aquatic macrophytes in aquaculture. In: *D. Moriarty and R.S.V. Pullin*, Editors, *Detritus and Microbial Ecology in Aquaculture*, *ICLARM Conf Proc*: 3-11-385.

8. Ray AK, Das I (1995) Evaluation of dried aquatic weed, *Pistia stratiotes* meal as a feedstuff in pelleted feed for rohu, *Labeo rohita* fingerlings. *J Appl Aquacult* 5: 35-44.

9. Valente LMP, Gouveia A, Rema P, Matos J, Gomes EF, et al. (2006) Evaluation of three seaweeds *Gracilaria bursa-pastoris, Ulva rigida* and *Gracilaria cornea* as dietary ingredients in European sea bass (*Dicentrarchus labrax*) juveniles. *Aquaculture* 252: 85-91.

10. Bag MP, Mahapatra SC, Rao PS, Chakraborty D (2012) Evaluation of growth performance of tilapia (*Oreochromis mossambicus*) using low cost fish feed. *International Journal of Biochemistry and Biotechnology* 1: 150-155.

11. Mukherjee AK, Kalita P, Unni BG, Wann SB, Saikia D, et al. (2010) Fatty acid composition of four potential aquatic weeds and their possible use as fish-feed. *Food Chem* 123: 1252-1254.

12. Bag MP, Mahapatra SC, Rao PS, Chakraborty D (2011) Making aquatic weed *lemna* as potential feed for *Nile tilapia* (*Oreochromis niloticus* L.) and its impact on fatty acid profile. *International Research of Pharmacy and Pharmacology* 1: 194-202.
13. AOAC, Helrich K (1990) Official Methods of Analysis: Parts 1-2. The Association, Arlington, VA, USA.

14. Zar JH (1999) Biostatistical analysis. (4th edn) Pearson Education, Englewood Cliffs, NJ, USA.

15. Duncan DB (1955) Multiple range and multiple F-tests. Department of Statistics and Statistical Laboratory, Virginia Agricultural Experiment Station, USA.

16. Sithara K, Kamalaveni K (2008) Formulation of low-cost feed using azolla as a protein supplement and its influence on feed utilization in fishes. Current Biotica 2: 212-219.