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Formulation of low-cost Fish feed using locally available agro-based wastes and its efficacy on growth performance of common Carp (*Cyprinus carpio* L.) - A case study from Apatani landscape of Arunachal Pradesh in Northeast India

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Abstract

The present study was done to formulate a low-cost fish feed using locally available agro-based waste, and to test its efficacy on growth of common carp (Cyprinus carpio). The study was done in context of increasing fish production in the rice-fish system of the Apatani landscape of Arunachal Pradesh in Northeast India. Nutrient content analyses of the formulated fish-feed showed it to be comparable with the standard feed material. Efficacy test of the formulated feed under laboratory condition showed that specific growth rate and condition factor of the stocked fish were significantly more when it was fed with a low dose of the formulated feed (i.e., @ 3% of the initial body weight). Overall, the study highlighted the possibility of increasing fish production in the rice-fish system of Apatani Plateau by exploiting the existing agro-based wastes. This may help in upliftment of the rural economy and sustainability of the region.

Keywords: Low cost fish-feed, Agricultural waste product, Growth performance, *Cyprinus carpio*, Rice-fish system, Apatani Plateau.

Introduction

Paddy-cum-fish culture is practiced in many parts of India, viz., Kerala, West Bengal Arunachal Pradesh and Tripura[1-3]. In India, the agrarian *Apatani* hill tribes settled in the lower Subansiri district of Arunachal Pradesh (Figure-1) are the only Indian tribal farmers who traditionally practice paddy-cum-fish culture since past 50 years. Agro-chemicals and fish-feed are not administered in the agro-ecosystem during the culture period, which makes it unique in the context of production. The fishes (*Cyprinus carpio*) are cultured along with the local rice cultivars viz., *Amo, Mypia* and *Pyapee* in the paddy fields. The fish depend on the natural feed such as plankton, periphyton, and other feeding materials available in the rice field. However, short duration of the rearing period and perhaps limited nutrition in the rice-fish system do not allow greater fish production during the rice-fish culture period. As a result, only 150 to 250 kg ha^{-1} of fish (*C. carpio*) per season are harvested from the system[2], which is much below the fish yield per hectare in similar systems in China[4,5]. Therefore, it calls for formulation of a suitable fish diet that can be administered in the rice-fish system as supplementary feeding material that would increase fish production.

In the present study, we prepared a fish-feed formulation using locally available agro-based wastes from the Apatani Plateau. This was followed by nutrient analyses of the feed formulation and an efficacy test of the formulated feed on growth performance of the stocked fish, *C. carpio*. Efficacy test was performed to optimize the proportion of feed for supplementation in the rice-fish system that might be appropriate for optimal fish growth without disrupting the natural ecological balance within the rice-fish system.

Materials and Methods

Selection of raw materials: For formulating the low cost fish-feed, commonly available agro-based wastes in the Apatani landscape were selected viz., (1) fermented residual rice after preparation of *Apong* - a local rice beer, (2) periphytic algal clumps formed in rice-field water near the rice rhizosphere. Besides, small quantity of garlic (*Allium sativum*) was also used, as it has antioxidant property[6]. It may be mentioned here that garlic is not locally grown by the *Apatani* people but is commonly used by them as spice and is purchased from the local market.

Analysis of nutrient content of the locally available ingredients used for fish-feed formulation: The nutrient contents of the rice residues of '*Apong*' and the rice field algal mass were assessed on dry weight basis (oven dried at 70°C for 48 hours) following standard methods[7-9].

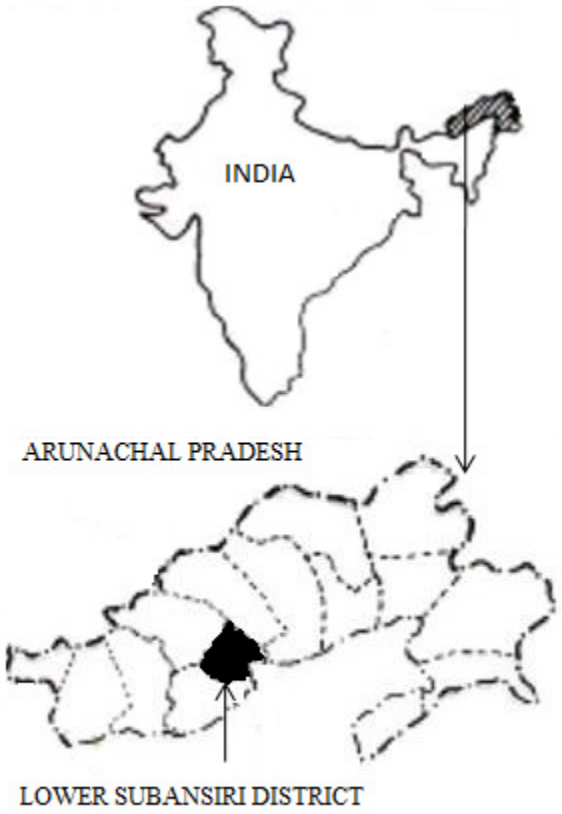

Figure-1
Map showing the location of the Apatani Plateau

Fish-feed formulation: The steps involved in the process are mentioned below: Step 1: Drying the fish-feed ingredients i.e., the rice residues, algal mass and garlic in an oven at 70°C for 48 hrs. Step 2: Grinding the dried ingredients separately into powder form using a grinder. Step 3: Mixing the powdered ingredients in the proportion 1(rice residue): 0.5 (algal mass): 0.01 (garlic). Step 4: Preparing soft dough of the powdered mixture following the proportion as mentioned above by adding appropriate quantity of clean water (at normal room temperature). Step 5: Making pellets of suitable sizes from the fresh dough using a pelletizer. Step 6: Drying the pellets in an oven at 60°C for 24 hours.

Analysis of nutrient content of the feed pellets: The nutritional value of the fish-feed formulation was analyzed for their nutrient content at dry phase (oven dried at 60°C for 24 hours)[7-9].

Efficacy test of the feed pellets under laboratory condition: In order to carry out the efficacy test of the formulated feed, fish growth experiment using candidate species in aquarium condition was performed in the laboratory during December, 2014. The feeding trial was carried out for a period of four weeks in four experimental aquaria (30 L capacity). Fries of *Cyprinus carpio* of sizes ranging from 2.5-3.5 cm were collected from the nearest fish farm, and were acclimatized for 48 hours in the aquaria. This was followed by stocking the fries in the experimental aquaria under different treatments @ 12 individuals per aquarium. Three feeding treatments using pelleted feed respectively @ 3% (Treatment 1), 5% (Treatment 2), and 7% (Treatment 3) of initial body weight of the stocked fishes were tested simultaneously. The fishes were fed twice with the fixed daily ration respectively at 08:30 hr and 17: 30 hr. One aquarium with no supplementation of feed was used as control. It is assumed that in the control aquarium, the stocked fish survived only on the available plankton communities present in the aquarium water. At the end of each week, the treated fishes (each group with three replicates) from different experimental aquaria were measured for various morphometric and growth parameters[10-14]. The water in all the experimental aquaria was changed once during 15th day of stocking.

Assessment of water quality in the aquaria: Water quality parameters, which are generally considered for fish culture, were analyzed for three times following standard methodologies[15]. The first set of water analysis was done before stocking the fish in the aquaria to find out suitability of the water for the aquarium experiment. Second set of analysis was

done on 14th day of stocking and the 3rd set on 28th day of stocking.

Statistical analysis: One-way ANOVA was performed to test the growth response, nutrient utilization capacity and survival parameters of the stocked fish under different feeding treatments. Regression model was run to explore the relationship of growth and survival parameters of the stocked fish with different feeding treatments. All the statistical analysis was performed using MS Excel and PAST 3.04[16].

Results and Discussion

Nutrient contents of both the locally available agro-based wastes used as fish-feed ingredients and the formulated fish-feed using the agro-based wastes and comparison of nutrient contents of the formulated fish-feed with standard fish-feed is represented in Table-1. The formulated feed contained high dietary protein (22.92%) which is considered suitable for better growth rate in fish[17]. Carbohydrate, although not so essential in fish feed[18], is included in aquaculture diets for their binding activity during feed manufacturing. In this regard, less carbohydrate content (2.39%) in the prepared feed is also considered suitable. Lipids content was less (3.35%) as compared to the general fish-feed standard. Besides, trace amounts of minerals like sodium and potassium, and traces of Vitamin C were also detected in the formulated fish-feed. However, greater concentration of phosphorous (7.36%) in the formulated feed cautions us against too much supplementation of the formulated fish-feed into the rice-fish culture system, which otherwise, might decrease the existing N: P ratio of the rice field water and would facilitate the dominance of nuisance Cyanophyceae algae[19] by replacing the palatable algal species from the rice-fish system.

Table-2 shows the feeding response, growth response, nutrient utilization and survival parameters of *Cyprinus carpio* fry fed with varying quantities of the prepared fish-feed in experimental aquaria. It revealed satisfactory feeding and 100% survival under all the treatments. Body weight, body length, standard length and body depth of the fries showed better performance under Treatment 2 beyond which feed supplementation (Treatment 3) had a negative effect on fish growth particularly on body length and body depth as shown in Figures-2A and 2B respectively. However, highest value of feed conversion ratio (FCR) and lowest values of condition factor (K) and specific growth rate (SGR) under Treatment 2 indicates less assimilation capacity and less suitable habitat condition for the stocked fish and a low fish growth rate in this treatment. SGR and K of the stocked fish were significantly more under Treatment 1 which also had lowest FCR and excellent feeding response as shown in Table-2 and Figures- 2C and 2D thereby showing better growth rate due to better nutrient assimilation accompanied by better habitat condition of the stocked fish in Treatment 1.

Table-1
Nutrient contents (%) of locally available agro-based wastes used as fish-feed ingredients and the formulated fish-feed using the agro-based wastes and comparison of nutrient contents of the formulated fish-feed with standard fish-feed

Nutrient content (%)	Agro-based wastes		Formulated fish-feed using the agro-based wastes	Nutrient contents of standard fish-feed as per Hassan, 2015
	Fermented residual rice after preparation of '*Apong*'	Periphytic algal clumps formed in rice-field water near the rice rhizosphere		
Carbohydrate	0.001	0.017	2. 39	Not very essential but may contain 15-20%
Protein	30.3	3.25	22.92	18-50%
Fat	0.1	0.01	3.35	10-25%
Calcium	0.01	0.06	1.15	Trace amount
Phosphorus	3.9	3.40	7.36	< 1.5%
Sodium	0.03	0.10	0.30	Trace amount
Potassium	0.3	0.63	1.27	Trace amount
Vitamin C	0.06	0.05	0.04	Trace amount

The aquaculture experiment revealed that the stocked fish would perform better in terms of their feeding response, daily growth rate, nourishment and habitat condition when they are fed with minimum dose (i.e., @ 3% of their initial body weight; Treatment 1). It may also be mentioned here that as the feed had greater concentration of P, lower dose of the feed supplementation would also help in maintaining the existing ratio of N and P in the rice field water and the diversity of existing algal and zooplankton communities in the rice-fish system, that act as natural live feed for the stocked fish. Minimum supplementation of the formulated feed would help the stocked fish to grow better by feeding not only on the supplementary feed but also on the existing diverse natural live feed from the rice-fish system. This would help in sustainable utilization of the natural resources from both within (algal clumps in the water-logged rice field) and outside (left over of fermented rice after preparation of the '*Apong*') the rice-fish system by the stocked fish leading to increased fish production.

Table-3 shows water quality parameters before and after supplementing the prepared fish-feed for four weeks in the experimental aquaria and its comparison with water standards for freshwater fisheries. Efficacy test of the formulated fish-feed on the water quality parameters showed variations under different treatments, though no clear-cut trend was observed. However except the water temperature, the water quality of all the experimental aquaria was within the fishery standards[20, 21]. This was due to the seasonal effect as the experiment was conducted during the cold month of December, 2014.

Table-2
Feeding response, growth response, nutrient utilization and survival parameters of *Cyprinus carpio* fry fed with varying quantities of the formulated fish-feed in experimental aquaria

Parameters		**Control**	**Treatment1 (feeding @ 3% of the initial body weight of the stocked fish)**	**Treatment2 (feeding @ 5% of the initial body weight of the stocked fish)**	**Treatment3 (feeding @ 7% of the initial body weight of the stocked fish)**	**F-ratio**
Feeding response		-	Excellent	Good	Good	-
Growth response	Body weight (gm)	4.96 ±0.25	5.68 ±0.08	5.78 ±0.07	5.16 ±0.33	2.13
	Body length (cm)	7.11 ±0.20	7.33 ±0.11	7.60 ±0.09	7.28 ±0.15	7.64**
	Standard length (cm)	5.83 ±0.10	6.01 ±0.03	6.33 ±0.06	5.74 ±0.13	1.06
	Body depth (cm)	2.06 ±0.05	2.08 ±0.03	2.14 ±0.05	2.07 ±0.03	6.74**
	Specific growth rate (SGR) (% day^{-1})	2.07 ±0.77	5.18 ±1.34	1.54 ±0.37	4.11 ±0.84	3.62*
Nutrient utilization	Feed conversion ratio (FCR)	-	2.76 ±0.24	26.35 ±14.75	9.96 ±2.76	2.82
Survival parameters	Survival rate (%)	100	100	100	100	-
	Condition factor (K)	1.39 ±0.08	1.45 ±0.07	1.32 ±0.05	1.34 ±0.03	6.69**

Mean ±SE; n=12; **p<0.01; * p<0.05

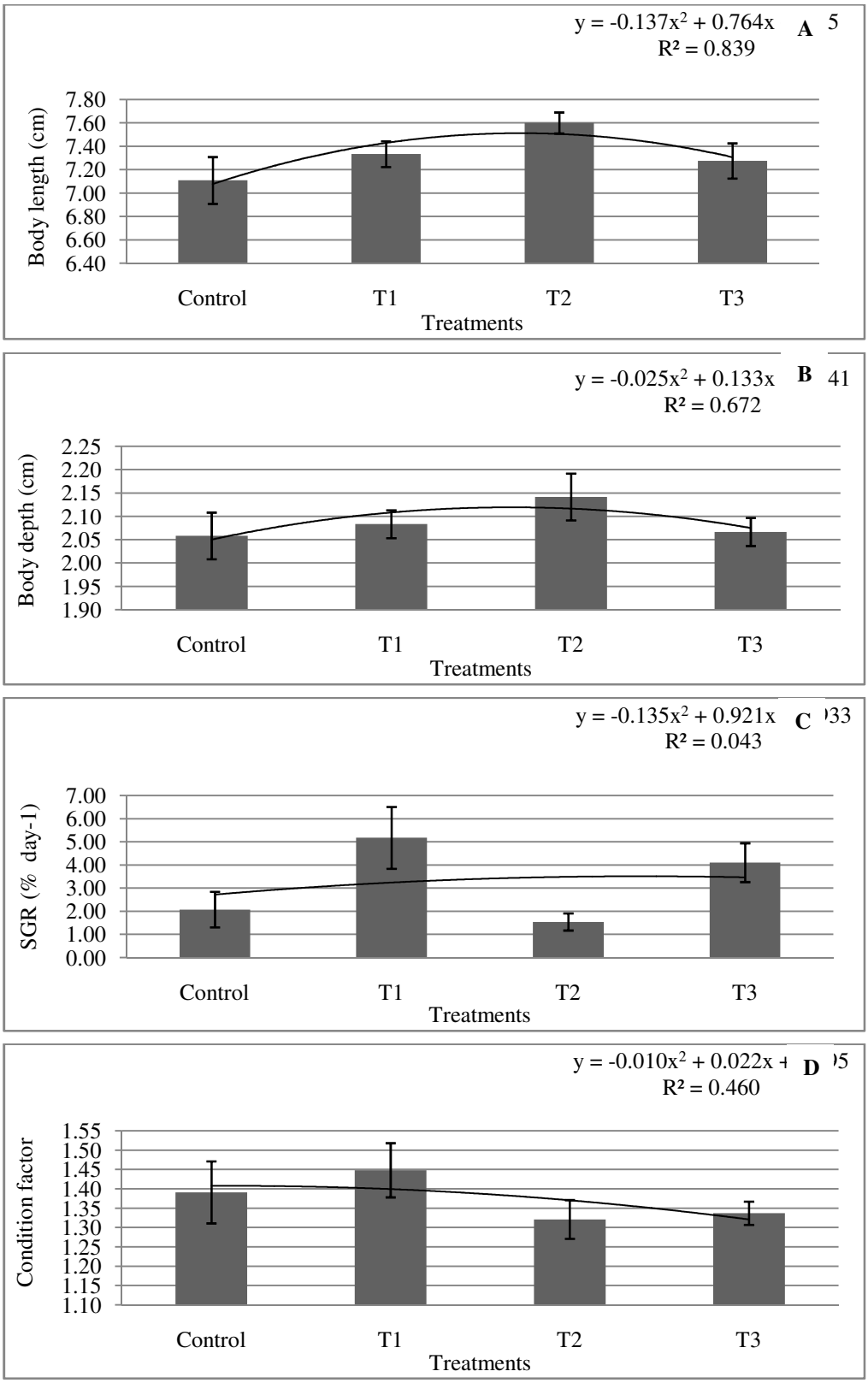

Figure-2
Changes in body length (A), body depth (B), specific growth rate (C) and condition factor (D) of *Cyprinus carpio* after four weeks of feeding with the formulated fish-feed under different feeding treatments in experimental aquaria

Table-3
Water quality parameters before and after supplementing the formulated fish-feed for four weeks in the experimental aquaria and its comparison with water standards for freshwater fisheries

Parameters	***Quality of water which was used for the aquaria experiment before stocking the fish in the experimental aquaria**	****Water quality in experimental aquaria after four weeks of supplementation of the prepared fish-feed**				**Standards of water properties for warm freshwater fisheries in pond as per**	
		Control	**Treatment 1**	**Treatment 2**	**Treatment 3**	**Boyd, 1998**	**Das *et al*., 2015**
Water temperature (°C)	20	17±1.0	19±1.0	18.5±0.5	15.5±0.5	-	25.0-32.0
pH	6.5	7.33±0.08	7.44±0.17	8.02±0.37	7.84±0.07	7.0-9.0	6.5-8.5
Dissolved oxygen (mgl^{-1})	6.12	9.97±1.11	9.40±0.20	8.68±0.98	9.49±1.25	5.0-15.0	5.0-10.0
Biological oxygen demand at 20°C for 3 days ($mg\ l^{-1}$)	0.88	6.49±0.78	6.08±2.50	4.09±1.52	4.80±0.61	-	<10.0
Free carbon dioxide ($mg\ l^{-1}$)	10.09	9.99±1.33	7.99±1.33	8.65±1.33	8.99±0.33	1.0-10.0	<3.0
Nitrate-N ($mg\ l^{-1}$)	0.2	2.51±0.66	4.22±1.63	2.45±0.74	4.43±0.87	0.2-10.0	0.1-3.0
Phosphate-P ($mg\ l^{-1}$)	0.29	0.14±0.0001	0.15±0.002	0.18±0.026	0.19±0.06	0.005-0.2	0.05 – 2.0

Mean ±SE; *n=1(Analyses of water quality from the water source before stocking the fish in the experimental aquaria); ** n=2 (Analyses of water quality of the experimental aquaria at 14^{th} and 28^{th} day of stocking the fish)

Conclusion

Overall, the study highlighted the possibility of increasing the secondary productivity of fish in the rice-fish system of Apatani Plateau by exploiting the existing agro-based wastes which would definitely result in more per capita fish-protein consumption and better economic returns to the local people of the Apatani landscape in sustainable and environmental friendly ways. However, further studies following on-farm feeding trials would enable us towards better understanding of the growth performance and habitat condition of the stocked fish, in addition to the overall ecology and economy of the Apatani rice-fish system.

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