Technical Bulletin No. 42

Three Decades (1981 - 2010) of Research on Fish Nutrition At ICAR Research Complex for Goa

Compiled and Edited By
Prafulla Kumar Naik, Bijaya Kumar Swain, Narendra Pratap Singh

CELEBRATING 25 Years Silver Jubilee Publication

ICAR Research Complex for Goa
(Indian Council of Agricultural Research)
Old Goa - 403 402, Goa, India.

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निदेशक
Dr. Narendra Pratap Singh
Director

Foreword

Feed is one of the most important components in aquaculture production and the economics production of the fish mainly depends on the cost of the feed. Goa has many small and large fresh water bodies, which hold a good scope for fish production. Besides, the small and marginal farmers are coming forward to keep ornamental fish as a source of supplemnatary income. In these situations, scientific efforts for effective usage of the existing feed resources and strategic approaches for adoption of new technologies are highly essential. Use of locally available conventional and nonconventional feed ingredients in the formulation of nutritionally balanced feeds, is one the best alternative to reduce the cost of the feed for sustainable fish production. Besides, live feed can provide the required nutrients in a more natural manner by which wastage and deterioration of culture medium can be reduced considerably.

ICAR Research Complex for Goa, Old Goa has the responsibility of increasing the fish production and productivity of the state by conducting applied and strategic research. Research has been conducted in this institute on nutrient requirements, feed and feed ingredients, feed additives and supplements, diet formulations for different fish etc., which are avialble in different Annual Reports of the Institute.

I am happy that the scientists of this Institute have taken the initiatives to compile the research findings of the three decades (1981-2010) of research on fish nutrition from different Annual Reports of the Institute and to publish in the form of a Technical Bulletin so that all the information will be easily avilable to the readers.

I congratulate all the authors for this effort and am confident that this publication will be a very useful resource material for the researchers, extension workers, students and farmers for planning their future work.

(Narendra Pratap Singh)

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Preface

NUTRITION is the vital determinant of the cost effective fish production. During the last three decades (1981-2010), scientists of this institute have conducted significant research works, which are available in different Annual Reports of the Institute. The areas of fish nutrition on which most of the resaerch works conducted in this Institute are nutrient requirements for different fish, feeds and feed ingredients for fish, feed additives and supplements and diet formulations for different fish.

Therefore, effort was made to compile the earlier research work of the Institute on fish nutrition and to present in the form of a Technical Bulletin 'Three Decades (1981-2010) of Research on Fish Nutrition at ICAR Research Complex for Goa' for easy reference of the readers. All the information has been given in this Technical Bulletin under different headings like nutrient requirements for different fish, feeds and feed ingredients for fish, feed additives and supplements, and diet formulations for different fish. Besides, for easy references and future research work, the key findings of the experiments have been presented separately as salient research findings along with the references.

We anticipate that this Technical Bulletin would be useful in providing scientific information in one place for the researchers, extension workers, students and farmers during panning of their future work for the enhancement of the fish production of the state.

- PK Naik, BK Swain, NP Singh

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We are grateful to Dr. N. P. Singh, Director, ICAR Research Complex for Goa, Goa for taking keen interest and encouraging for the compilation of the research findings of the three decades (1981-2010) of research on fish nutrition from different annual reports of the Institute and to publish in the form of a Technical Bulletin to make the information easily avilable to the readers.

We are thankful to Dr. A. R. Bhattacharyya, Dr. D. G. Dhandar, Dr. P. G. Adsule and Dr. V. S. Korikanthimath, the Ex-Directors of this institute for providing facilities for research work on fish nutrition during their respective tenure.

We record our deep appreciation to Dr. S. Subramanian, Principal Scientist (Fish and Fishery Science) (Retd.) and Dr. K. N. Mohanta, Principal Scientist (Fish and Fishery Science) and other scientists and workers, whose research findings have been compiled in this Technical Bulletin for their significant contributions in the field of Fish Nutrition.

We acknowledge all the scientists, technicians and supporting staffs of the Institute for providing support in conducting research work and complilation of this Technical Bulletin.

- PK Naik, BK Swain, NP Singh

Abbreviations

AIA	: Acid insoluble ash
Ca	: Calcium
cal	: Calori
CD	: Critical difference
CF	: Crude fiber
CP	: Crude protein
CSF	: Carp starter feed
DE	: Digestible energy
DM	: Dry matter
EE	: Ether extract
FCE	: Feed conversion efficiency
FCR	: Feed conversion ratio
FRP	: Fibre-reinforced plastic
g	: gram
GE	: Gross energy
GNC	: Ground nut cake
h	: Hour
ha	: hector
IU	: International unit
K	: Condition factor
Kcal	: Kilo calorie
kg	: Kilogram
L	: Litre
m2	: meter square
mg	: milligram
ME	: Metabolizable energy
Min	: Minimum
MM	: Mineral mixture
NDF	: Neutral detergent fiber
NFE	: Nitrogen free extract
NPR	: Net protein retention
OFF	: Ornamental fish feed
PER	: Protein efficiency ratio
ppm	: Parts per million
PWG	: Percent weight gain
SGR	: Specific growth rate
SEM	: Standard error of mean
TA	: Total ash

Contents

Introduction

GOA lies between $15^0$48" and $14^0$53" north latitude and between $74^0$20' and 73^0 40' east longitudes. It is a part of third zone of west coast region and has a coastline of 105 km from north to south. The range of temperature, relative humidity and total average annual rain fall is about 18-35^{0}C, 40-99% and 2500-4000 mm, respectively.

Goa has a population of about 15 lakhs with almost equal urban and rural population. Further, being an important tourist spot, on an average 15 lakhs tourists visit the state every year. Rice an fish is the staple food of the Goans and they mostly prefer the marine fish. However, the tourists of Goa generally prefer both marine and fresh water fish. Besides, ornamental fish culture has emerged as a fast growing source of income generation for the small and marginal farmers of Goa.

Goa has many small and large fresh water bodies, which holds a good scope for fish production. Feed is one of the most important components in the aquaculture production and the economics of the fish production mainly depends on the cost of the feed. In this situation, scientific efforts for the effective usage of the existing feed resources and strategic approaches for adoption of the new technologies are highly essential. Use of locally available conventional and nonconventional feed ingredients in the formulation of nutritionally balanced feeds is one the best alternative to reduce the feed cost for sustainable fish production. Besides, live feeds can provide the required nutrients of the fish in a more natural manner so that the wastage and deterioration of the culture medium can be reduced considerably.

A lot of research work has been conducted in this Institute on fish nutrition, which are avilable in different Annual Reports. Therefore, all the information of the research work conducted during the last 30 years (1981-2010) in this institute on fish nutrition has been compiled to bring at one place so that it will be easily avialble to the redaers. In this Technical Bulletin, the research work on fish nutrition has been presented under different chapters *viz*. nutrient requirements for different fish, feeds and feed ingredients for fish, feed additives and supplements, diet formulations for different fish, salient research findings and references; so that it will be a very useful resource material for the researchers, extension workers, students and farmers for panning their future work.

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Nutrient requirements for different fish

Protein and lipid requirements of blue gourami (*Trichogaster trichopterus*) *(Anonymous, 2005-06)*

Nine purified diets (casein-gelatin-dextrin based) were prepared with three levels of protein (30, 35 and 40, %) and three levels of lipid (6, 5 and 10; %). The growth and nutrient utilization of blue gourami was better ($P<0.05$) in fish fed 35 per cent protein and 8 per cent lipid. It was concluded that the optimum protein and lipid requirements of blue gourami fingerling were 35% and 8%, respectively.

Effect of carbohydrate on growth and nutrient utilization of blue gourami (*Trichogaster trichopterus*) *(Anonymous, 2005-06)*

The effect of different levels of carbohydrate on the growth performance of blue gourami fingerlings was studied for a period of 60 days by maintaining the protein and lipid content of the diet 35 per cent and 8 per cent, respectively. The different carbohydrate levels in the diets were 20, 25, 30, 35, 40 and 45 per cent. The 500 L capacity indoor fibre-reinforced tanks with 100 L of water (static system) were used for the experiment. The growth and nutrient utilization of fish fed 40 per cent carbohydrate level was better ($p<0.05$) than the other carbohydrate level fed groups. It was concluded that blue gourami fingerlings required 35 per cent protein, 8 per cent lipid and 40 per cent carbohydrate in the diet.

Effect of different sources of carbohydrate on growth and nutrient utilization of blue gourami (*Trichogaster trichopterus*) *(Anonymous, 2005-06)*

To find out the effect of different sources of carbohydrate *viz.* corn starch, wheat flour, potato starch, tapioca powder and rice flour on growth performance of blue gourami fingerlings, an experiment was conducted for a period of 60 days. In all experimental

diets, 35 per cent protein, 8 per cent lipid and 40 per cent carbohydrate levels were maintained. After 30 days of rearing, it was observed that the growth of fish fed on potato starch as carbohydrate source was maximum than the diets containing other sources of carbohydrate.

Effect of dietary vitamin E on growth and gonadal maturity of blue gourami (*Trichogaster trichopterus*) *(Anonymous, 2007-08)*

A basal diet with 35 per cent CP and 3.54 kcal/g GE was prepared and Vitamin E (tocopherol acetate) was added at 0 (control), 100, 150, 200 and 250; mg/kg diet, respectively. Results indicated that the weight gain and SGR of male and female blue gourami were highest in fish, fed diet containing 150 mg/kg vitamin E. It was observed that at the dietary Vitamin E level of 150 mg/kg diet, the gourami females of different groups had maximum swollen abdomen. These results suggested that the optimum Vitamin E requirement of blue gourami brood stock was 150 mg/kg in the diet for better growth and gonadal maturity.

Protein and lipid requirement of guppy (*Poecilia reticulata*) *(Anonymous, 2006-07)*

Nine isocaloric (3.5 kcal/g) casein-gelatin-dextrin based purified diets were formulated using three levels of protein (30, 35 and 40; %) and three levels of lipid (6.8 and 10, %). Guppy fingerlings were fed *ad lib.* four times a day for a period of 60 days in a static water system with 50 L of rearing water medium. It was observed that the guppy fingerlings required 30 per cent protein and 10 per cent lipid in their diet.

Determination of protein and lipid requirements of sword tail (*Xiphophorus hilleri*) *(Anonymous, 2007-08)*

Nine isocaloric (4.0 kcal/g) diets were formulated by using three levels of protein (30, 35 and 40; %) and three levels of lipid (6, 8 and 10; %) and fed *ad lib.* to sword tail, (*X. hilleri*) fingerlings for a period of 60 days in a static water system with 100 L of rearing water medium. It was observed that sword tail fingerlings required 40 per cent protein and 6 per cent lipid in their diet to attain the maximum growth.

Determination of vitamin E requirement of sword tail (*Xiphophorus hilleri*) *(Anonymous, 2008-09)*

An experiment was conducted to evaluate the effect of vitamin E supplementation at the levels of 0 (control), 100, 200, 300 and 400; mg/kg diet on growth and breeding performance of sword tail. Results indicated that although the growth performance was better ($P<0.05$) in fish supplemented with vitamin E at the level of 300 mg/kg diet, the breeding performance was better ($P<0.05$) at 400 mg/kg diet.

Determination of protein and lipid requirements of black molly (*Poecilia latippina*) *(Anonymous, 2008-09)*

Nine iso-caloric (4.0 kcal/g diet) casein-gelatin-dextrin based semi-purified diets with three levels of protein (30, 35 and 40; %) and three level of lipid (6, 8 and 10, %) were fed *ad lib.* to fish for a period of 60 days. For rearing the fish, flow-trough FRP tanks containing 100 L water was used. Results indicated that the fish fed 40% protein and 6% lipid had significant growth and nutrient utilization in terms of weight gain, SGR, FCR and PER.

Protein and lipid requirements of angel fish (*Petrophyllum scalare*) *(Anonymous, 2009-10)*

Nine isocaloric (4.0 kcal/g diet) casein-gelatin-dextrin based semi-purified diets with three levels of protein (30, 35 and 40, %) and three levels of lipid (6, 8 and 10, %) were formulated and analyzed. The experimental diets were fed *ad lib.* for a period of 60 days to the fish in triplicate with 10 fish/ replicate. For rearing the fish, outdoor FRP tanks containing 200 L water was used with a closed water system. The excreta and the left over feed were removed through siphoning and the amount of water removed during the cleaning process were replenished again by seasoned well water. The tanks were cleaned in every week and the water was exchanged fully on a weekly basis. Results indicated that the fish fed with 30 per cent protein and 6 per cent lipid had better ($P<0.05$) growth and nutrient utilization in terms of weight gain, SGR, FCR and PER.

3

Feeds and feed indegredents for fish

Aquatic weeds as fish feed (*Subramanian, 1981*)

The possibilities of conversion of aquatic weeds *i.e. Salvinia* and water hyacinth (*Eichornia*) into palatable and nutritious fish feed involving a process of microbial bioconversion was studied. For each of the weed, three natural ponds (0.01, 0.05 and 1.00; ha) were selected and monthly samples of water and weed were collected for the determination of parameters relating to the physical conditions of pond, chemical nature of water and biological aspects of weed. Biomass for both weeds showed a definite trend of increasing growth rate in all the ponds with a few exceptions of minor negative growth rate. Highest biomass production recorded for *Salvinia* and water hyacinth was 0.712 kg/m^2 and 2.050 kg/m^2, respectively. The DM% of *Salvinia* and water hyacinth was 6.7-8.3 and 7.8-11.5, respectively. The total nitrogen content of *Salvinia* and water hyacinth were 0.82% and 1.80%, respectively. The total carbon was 33.17-36.8% for *Salvinia* and 34.20-38.1% for water hyacinth.

Locally available feed ingredients for fish and prawns *(Mohanta et al., 1997-98; Mohanta et al., 1998-99; Mohanta et al., 1999-2000)*

A survey was made to find out the availability and cost of the feed ingredients (Table 1) which include rice bran, wheat bran, groundnut oil cake, coconut oil cake, cotton seed cake, prawn shell waste, fish meal, press mud, maize, sugarcane jaggery, spent yeast, azolla, tur chunni, gram chunni, blood meal, bone meal, silkworm pupae and brewery grain waste.

Table 1. Availability and cost of different feed ingredients (as on January, 1998).

Feed ingredients	Approx. cost (Rs. /kg)	Source (s)
Fish meal	8.00	Sagar fish meal, Balli; Goa Bagrayatdar Society,
Groundnut oil cake	8.50	Ponda; Valfran Agencies, Margao; Tapu Topan, Margo
Wheat bran	6.00	
Cotton seed cake	6.50	
Tur chunni	6.00	
Gram chunni	5.70	
Rice bran	1.50	Rice mill, Carambolim
Fish oil	280.00	Sumac agencies, Curchorem, Goa
Silk worm pupae	9.50	
Meat cum bone meal	6.50	
Sterilized liver meal	6.00	
Brewery grain waste	3.00	UB, Bethora, Ponda; Arlem breweries, Madgaon
Spent yeast		UB, Bethora, Ponda; Arlem breweries, Ponda Real distillaries, Nuvem; Impala distillaries, Salcette
Dried form	30.00	---
Liquid form	4.00	---
Press mud		Sanjeevani sugar factory, Usgaon, Tisca, Goa
Sugarcane jaggery		
Maize	5.70	Goa Bagaytdar Society, Ponda
Coconut oil cake	4.00	Coconut oil mill, Patto, Panaji
Chicken liver (wet weight)	50.00	---
Prawn meal (dry weight)	180.00	---
Mussel meat (wet weight)	100.00	---
Squid meat (wet weight)	80.00	---
Oyster meat (wet weight)	100.00	---

Chicken liver meal, prawn meal, squid meal, mussel meal and oyster meal had higher CP content (Table 2) but were costlier and can be used for the ornamental fish feed formulation, wherein the feed requirement is less.

Table 2. Proximate compositions (% DM basis) of locally available feed ingredients

Ingredients	DM	CP	EE	CF	TA	AIA	NDF	ADF
Fish meal	93.8	42.0	6.0	3.0	31.5	7.0	8.0	4.0
Prawn shell waste	93.7	32.0	1.5	22.5	40.6	8.5	18.0	8.0
Groundnut oil cake	95.4	42.0	9.0	8.5	6.9	2.8	4.0	4.0
Wheat bran	89.9	13.9	4.0	10.5	6.9	0.2	38.0	6.0
Cotton seed cake	91.9	26.0	8.0	21.0	14.0	1.2	42.0	24.0
Maize	91.1	9.0	4.0	2.2	1.9	0.6	6.0	2.0
Spent yeast	94.1	43.0	0.5	---	7.6	---	---	---
Brewery grain waste	91.4	26.0	15.5	15.5	3.0	0.6	52.0	14.0
Azolla	89.8	13.0	1.2	9.0	17.6	2.4	46.0	28.0
Press mud	76.7	9.0	1.5	3.0	12.0	6.5	18.0	22.0
Tur Chunni	91.3	12.5	2.2	31.0	14.0	9.2	32.0	38.0
Gram Chunni	91.8	11.0	1.8	20.0	11.3	7.9	48.0	48.0
Rice bran	92.3	12.8	13.8	13.8	10.5	2.5	8.0	3.0
Soybean meal	91.8	48.3	21.2	6.5	8.0	2.0	10.0	4.0
Rice polish	89.9	12.2	1.8	13.2	13.8	10.0	28.0	16.0
Rice bran	91.6	13.7	1.3	12.8	14.2	6.4	31.0	16.8
Chicken liver	15.20	66.06	23.50	2.00	10.40	1.60	---	---
Prawn meal (dried)	73.30	64.31	5.00	1.20	14.08	7.20	---	---
Mussel meal	13.71	57.16	13.40	1.00	9.40	0.60	---	---
Squid	11.57	70.10	5.00	1.10	10.0	0.20	---	---
Oyster	13.80	48.00	10.10	1.20	17.0	2.00	---	---

***Spirulina* and *Moina* as fish feed** (*Anonymous, 2005-06; Anonymous, 2006-07; Anonymous, 2008-09*)

Spirulina platensis and *Moina* can be used as feed for different types of fish. *Spirulina platensis* contained more than 64 per cent CP, indicating its suitability as a rich source of plant protein. It was observed that *Spirulina* had positive feeding response on blue gourami, gold fish, angel fish and sword tail. Further, *Spirulina* was fed in powder form to guppy successfully both in fresh form and formulated feeds. *Moina* was fed successfully in live condition to guppy, gold fish, blue gourami and sword tail brood stock.

4

Feed additives and supplements

Effect of probiotic on the growth performance of rohu (*Labeo rohita*) fry (*Mohanta and Subramanian, 2000-01*)

The probiotics containing *Lactobacillus sp.* @ 600 billion CFU/kg of product was added to the basal carp feed (approximately 40% CP and 4.11 kcal/g energy) at 0.0 (D-1), 1.0 (D-2), 3.0 (D-3), 5.0 (D-4) and 10.0 (D-5), g/kg and tested on *Labeo rohita* fry to study the performance of the fish. The PWG, FCR, SGR and PER were higher in D-4 and D-5 than other diets (Table 3).

Table 3. Performance of rohu fry fed probiotics suppliemented diets.

Parameters	Experimental diets				
	D-1	D-2	D-3	D-4	D-5
PWG	197.28±4.695^{b}	191.06+3.445^{b}	189.67+4.747^{b}	237.39+4.085^{a}	221.48+8.310^{a}
FCR	1.50±0.037^{abc}	1.63±0.088^{a}	1.58±0.039^{ab}	1.25±0.027^{d}	1.34 ±0.047^{cd}
SGR	3.62±0.052^{bc}	3.46±0.113^{c}	3.53±0.054^{c}	4.05±0.040^{a}	3.88±0.086^{ab}
K	1.00±0.031^{a}	1.00±0.038^{a}	0.96± 0.038^{a}	1.03±0.015^{a}	0.90±0.015^{a}
PER	1.64±0.045^{bc}	1.53±0.083^{c}	1.64±0.045^{bc}	1.96±0.034^{a}	1.83±0.063^{ab}

Mean values bearing different superscripts in a row differ significantly (P<0.05).

The carcass moisture content in all the treatments ranged from 72.8 to 74.0 per cent and was lower than the initial value of 75.68 per cent (Table 4). There was increase in the final carcass CP and EE levels in all fish groups, when compared with the initial levels; however, the rate of increase was maximum in D-4. It was observed that the probiotic supplement @ 5 g/kg of basal feed increased the feed cost by about Rs. 3.70/- kg (from Rs. 15.65/- to 19.35/- per kg). However, there was 40 per cent increase in weight gain in the fish, fed diet supplemneted with probiotics at 5 per cent level (D-4) as compared to control diet (D-1).

Table 4. Carcass compositions of rohu fry supplementezd with probiotics

Parameters	Carcass composition (% DM basis)					
	Initial value	Experimental diets				
		D-1	D-2	D-3	D-4	D-5
Moisture	75.68	74.00	73.50	72.80	73.80	73.60
CP	58.25	61.75	63.50	64.75	65.25	64.75
EE	21.00	22.00	22.00	24.00	26.00	24.00
CF	1.30	1.20	0.86	0.93	0.78	0.84
TA	13.20	14.00	14.00	13.00	13.00	15.00

It was concluded that the probiotics containing *Lactobacillus sp.* @ 600 billion CFU/kg could be supplemented at the level of 5 g/ kg in the diet of rohu (*Labeo rohita)* fry for higher growth performance.

Effect of enzyme-probiotics supplement on growth performance, nutrient utilization and carcass composition of rohu (*Labeo rohita*) fry (*Mohanta and Subramanina, 2000-01*)

The commercial enzyme-probiotics (approx. cost Rs. 1.15/ g) containing enzymes amylase: 3,00,00,000 units, hemicellulase: 17,82,000 units, cellulase: 39,60,000 units, protease: 1,00,00,000 units, lipase: 16,50,000 units, betagluconase: 34,980 units and probiotic bacteria (*Lactobacillus spp*.) at the concentration of 300 billion viable colony forming unit (CFU) per kg of the product was added to the basal diet having 35.27 per cent of CP, at 0.0 (D-1), 1.0 (D-2), 3.0 (D-3), 5 (D-4) and 10 (D-5) g/kg levels. The growth performance was higher in the group fed diet D-3, when compared to other diets (Table 5).

The use of the enzyme-probiotics feed supplement had no adverse effect on the carcass composition of the fish (Table 6). It was observed that at the level of 3.0 g, enzyme-probiotics feed supplement (equivalent to about 0.9 billion CFU of *Lactobacillus* bacteria, amylase: 90,000 units, hemicellulase: 5,346 units, cellulase: 11,880 unis, protease: 30,000 units, lipase: 4,950 units and beta-gluconase: 105 units) per kg of basal feed, the growth performance, nutrient utilization and carcass composition of the *Labeo rohita* fry was higher.

Table 5. Performance of rohu fry fed enzyme-probiotics supplemented feeds

Parameters	Experimental diets				
	D-1	D-2	D-3	D-4	D-5
PWG	82.413±2.297^{b}	74.303±1.422^{b}	112.396 ±4.873^{a}	81.960 b ±3.151	79.766±3.492^{b}
FCR	2.127 ±0.058^{ab}	2.357±0.044^{a}	1.635 ±0.093^{c}	1.852±0.084^{bc}	1.749±0.0002^{bc}
SGR	1.716±0.035^{b}	1.585±0.220^{b}	2.140±0.067^{a}	1.708±0.053^{b}	1.674±0.056^{b}
K	0.983±0.013^{a}	0.901±0.010^{c}	0.965±0.008^{ab}	0.927±0.005^{bc}	0.972±0.011^{a}
PER	1.336±0.036^{bc}	1.204±0.023^{c}	1.752±0.107^{a}	1.620±0.0002^{ab}	1.620±0.000^{ab}

Mean values bearing different superscripts in a row differ significantly (P<0.05).

Table 6. Carcass compositions of rohu fry fed enzyme-probiotics supplemented diets

Parameters	Carcass compositions (% DM basis)					
	Initial value	Experimental diets				
		D-1	D-2	D-3	D-4	D-5
Moisture	75.50	75.10	74.60	74.80	73.90	74.40
CP	53.62	61.25	63.00	64.75	61.25	57.75
EE	16.00	20.00	18.00	20.00	19.00	18.00
CF	1.30	1.10	0.88	0.90	0.87	0.84
Ash	11.00	13.00	12.00	11.00	13.00	14.00

The enzyme-probiotics feed supplement at the level of 3.0g/ kg basal feed, increased the feed cost by Rs. 3.45/- per kg (from Rs. 15.90/- to Rs. 19.35/- per kg). However, there was 30 per cent more weight gain in fish of D-3 than the D-1. It was concluded that the enzyme-probiotics feed supplement could be supplemented at the level of 3 g/ kg in the diet of rohu (*Labeo rohita)* fry for higher growth performance.

Effect of different levels of yeast on the performance of angel fish (*Pterophyllum scalare*) (*Subramanian and Nirmale, 2003-04*)

Yeast was added to the basal diet at 0.0 (T-1), 1.0 (T-2), 2.0 (T-3), 3.0 (T-4), 4.0 (T-5) and 5.0 (T-6) per cent levels and fed to angel fish (*P. scalare)*. The mean weight of the fry was 2.04±0.75 g. The duration of the study was 60 days. The numbers of treatment were six

with three replicates in each tretament and 10 fish per replicate. The feeding rate was 5% of the initial body weight. The volume of water maintained was 100 L. The CP% (on DM basis) of the feed T-1, T-2, T-3, T-4, T-5 and T-6 was 43.31, 44.18, 45.06, 46.81, 47.68 and 49.43, respectively. In T-6, the fish fed 5% yeast, had better weight gain, FCR, SGR, PER and NPR, compared to other treatments (Table 7). It was concluded that the yeast supplemented at the level of 5% in the diet of angel fish had higher growth performance.

Table 7. Performance of angel fish supplemented with yeast

Treatment	PWG	FCR	SGR	PER	NPR
T-1	22.45	13.46	0.1465	0.1731	10.05
T-2	28.47	10.55	0.1813	0.2149	18.36
T-3	33.47	8.97	0.2089	0.2477	25.44
T-4	40.06	7.68	0.2432	0.2857	26.66
T-5	43.32	6.97	0.2601	0.3047	29.29
T-6	57.09	5.26	0.3268	0.3854	32.52
C.D (P=0.01)	12.686	2.729	0.065	0.09	5.752

Efficacy of binders on water stability, protein leaching and sinking rate of feed pellets and growth performance of rohu *(Labeo rohita)* fingerlings (*Anonymous, 2005-06*)
Five commercial binders *viz.* carboxy methyl cellulose, carageenan, alginic acid, guar gum and gum acacia were incorporated at 2 per cent level in a basal carp diet containing 35 per cent CP and 3.88 kcal/g DE and fed to rohu fingerlings (0.84 $\pm$ 0.01 g) for a period of 45 days in triplicate tanks (10 fish/ tank) at 3 per cent of their body weight. The ingredient compositions (on % DM basis) of the basal diet was fish meal (20%), ground nut oil cake (30%), prawn meal (10%), wheat bran (20%), maize (10%), vegetable oil (6%), mineral and vitamin mixture (2%) and binder (2%). Results revealed that the guar gum based diet had higher growth performance in rohu than the other binder supplemented diets.

5

Diet formulations for different fish

Evaluation of carp starter feed on *Labeo rohita* (*Mohanta et al., 1998-1999*)
Three iso-protein (approx. 31.77% CP and 2,600 kcal/ kg GE) carp starter feeds (CSF) *i. e.* (CSF-I, CSF-II and CSF-III) were formulated and analyzed for proximate compositions (Table 8).

Table 8. Physical and chemical compositions of carp starter feeds

Particulars	CSF-I	CSF-II	CSF-III
Physical compositions			
Ground nut cake	-	35	70
Fish meal	70	35	-
Wheat bran	10	10	10
Maize	11	11	11
Vegetable oil	2	2	2
Mineral & vitamin mix.	2	2	2
Binder (wheat flour)	5	5	5
Chemical compositions (% DM basis)			
DM	90.80	91.00	91.20
CP	31.73	31.73	31.73
EE	8.30	9.20	10.10
CF	4.30	6.50	9.10
TA	11.60	10.70	6.90
Energy (kcal/ kg)	2,613	2,648	2,683

In CSF-II and CSF-III, fishmeal was replaced by ground nut oil cake at 50 and 100 per cent level. The feeds were evaluated for the growth of carp fry (*Labeo rohita*). The duration of the study was two months. The growth performances was observed in every 15 days. The feeding ratio was 10% of the body weight of the fish and the feeding frequency was once daily at afternoon hours. The numbers of treatments were three and the numbers

of replicates in each treatment was four with 10 fish in each replicate. The volume of water in each experimental tank was 200 L. In CSF-I, only fishmeal was used as the main protein source. The growth performance of fish fed CSF-I, CSF-II and CSF-III are presented in Table 9.

Table 9. Performance of fish fed different carp starter feeds

Parameters	CSF-I	CSF-II	CSF-III
FCR	3.56	3.45	3.42
PWG	442.28	397.74	463.04
K	1.046	1.053	1.024
SGR	2.817	2.674	2.880
Cost in Rs. /kg	13.31	12.81	12.26

It was concluded that fish meal could be replaced 100 per cent by groundnut oil cake in the carp starter feed without hampering the growth performance of the carp fry (*Labeo rohita*).

Evaluation of carp starter feed on *Cirrhinus mrigala* (*Mohanta et al., 1999-2000*)
Three iso-protein (approximately 31% CP) carp starter feed (CSF) were formulated (Table 10) and tested on *Cirrhinus mrigala*.

Table 10. Physical and chemical compositions of carp starter feeds (CSF)

Particulars	CSF-I	CSF-II	CSF-III
Physical compositions			
Fish meal	70	35	-
Groundnut cake	-	35	70
Wheat bran	10	10	10
Maize	11	11	11
Minerals and Vitamins mixture	2	2	2
Binder	5	5	5
Vegetable oil	2	2	2

Chemical compositions (% DM basis)			
DM	90.60	89.93	91.10
CP	32.08	31.72	31.38
EE	8.40	9.30	10.20
CF	4.30	6.40	8.70
TA	12.20	9.80	7.40
Energy (Kcal/kg)	2,617	2,652	2,691
Growth performance of fish			
FCR	2.43	2.31	2.10
PWG	28.1	40.42	59.5
SGR	0.413	0.566	0.778
K	1.22	1.21	1.25
PER	1.281	1.360	1.5111
Cost/ kg	14.48	14.13	13.78

In CSF-I, only animal protein (fish meal) was used as major protein source. In CSF-II and CSF-III, animal protein source was replaced by plant protein source (groundnut oil cake) at the level of 50 and 100 per cent, respectively. These feeds were fed to carp *(Cirrhinus mrigala)* fingerlings to study the growth performances. The duration of the study was two months. The fish were fed at the rate of 5% of their body weight. There were three treatments (CSF-I, II and III) with four replicates in each treatment and 10 fish in each replicate. It was concluded that the animal protein source in starter carp feed could be replaced completely by plant protein source without affecting the growth performances of the carp fish. Therefore, the fishmeal (animal protein source), which is costlier and not available throughout the year, particularly during the monsoon season can be replaced by the groundnut oil cake.

Formulation of ornamental fish feed (*Anonymous, 1999-2000*)

Four iso-protein ornamental fish feeds (OFF) with 40 per cent CP were formulated (Table 11).

Table 11. Ingredient compositions (% DM basis) of the ornamental fish feeds (OFF)

Ingredients	OFF-I	OFF-II	OFF-III	OFF-IV
Chicken liver	25	--	--	--
Prawn meal	--	25	--	--
Mussel meal	--	--	35	--
Squid meal	--	--	--	20
Fish meal	25	25	25	25
Groundnut cake	20	20	20	25
Wheat bran	10	10	10	10
Maize	10	10	10	10
Mineral & vitamin mix.	03	03	03	03
Oil	2	2	2	2
Binder	5	5	5	5

All the above OFF along with two commercial feeds *i. e.* tubifex worm and brine shrimp flake were analyzed for proximate compositions (Table 12).

Table 12. Proximate compositions (on % DM basis) of ornamental fish feeds

Ornamental fish feeds	DM	CP	EE	CF	TA	AIA
Chicken liver based diet (OFF-I)	92.50	40.50	7.50	2.00	17.20	1.00
Prawn meal based diet (OFF-II)	93.10	40.00	3.50	3.20	19.80	5.20
Mussel meal based diet (OFF-III)	92.20	40.40	10.00	1.50	15.56	2.40
Squid meal based diet (OFF-IV)	91.90	40.15	5.50	1.00	16.10	3.00
Tubifex worm diet (OFF-V)	92.30	59.20	9.00	0.01	18.95	2.00
Brine shrimp flake diet (OFF-VI)	93.50	59.00	13.80	1.50	13.80	0.20

All the six feeds were fed to gold fish (*Carassius auratus*) at the level of 10 per cent of body weight for a period of one month. There were three replicates for each treatment (feed) with 10 fish in each replicate. The performnace of the fish fed on abvove six diets are provided in Table 13.

Table 13. Performance of fish fed different types of feeds

Parameters	OFF-I	OFF-II	OFF-III	OFF-IV	OFF-V	OFF-VI
CP (%)	40.50	40.00	40.40	40.15	59.00	59.00
Weight gain (g)	6.30	5.73	6.11	6.75	9.26	6.54
FCR	1.85	1.88	1.82	1.83	1.46	1.72
SGR	2.83	2.84	2.78	2.72	3.78	3.09
PER	1.350	1.324	1.373	1.361	1.159	0.982
Cost/kg of feed (Rs.)	88.75	58.70	226.30	147.85	3500	1150
Cost of production per kg biomass	177.50	110.35	411.66	269.08	5110.00	1978.00

The water quality parameters during the feeding of ornamental fish were studied and are presented in Table 14.

Table 14. Water quality parameters during the ornamental fish feeding trials

Ornamental fish feeds	Temp. (^{0}C)	pH	DO	NH4+ (ppm)	NO2- (ppm)	NO3- (ppm)	Alkalinity (m mo 1/1)
OFF-I	26.2-26.7	6.5- 6.8	3.9-4.3	075-2.0	0.25-0.75	10.0-37.5	0.7-1.1
OFF-II	26.4-26.6	6.5-6.7	3.7-4.1	075-3.0	0.50-0.75	10.0-25.0	0.6-1.2
OFF-III	26.3-26.8	6.5-6.8	4.1-4.4	1.0-4.50	0.25-0.50	12.5-37.5	08-1.0
OFF-IV	26.5-26.9	6.5-6.8	3.6-4.3	2.5-5.0	0.25-0.75	10.0-25.0	0.6-1.4
OFF-V	26.2-26.5	6.7-6.8	3.8-4.2	3.5-7.0	0.50-1.00	25.0-37.5	0.8-1.7
OFF-VI	26.1-26.6	6.5-6.8	3.9-4.3	5.0-7.5	0.25-0.75	12.5-25.0	0.7-1.3

It can be concluded that though the formulated ornamental fish feeds (chicken liver based, prawn meal based, mussel meal based and squid meal based) had comparable growth performance in gold fish, they were much cheaper than the commercial feeds (tubifex worm and brine shrimp flake).

Evaluation of ornamental fish feeds on blue gourami (*Trichogaster trichopterus*) (*Mohanta and Subrmanian, 2000-01*)

Four fresh ornamental fish feeds (OFF) *viz*. chicken liver based diet (T-1), prawn meal based diet (T-2), mussel meal based diet (T-3) and squid meal based diet (T-4) having approximately 40% CP and 4,000 cal/g (calculated) were formulated. The growth performance of blue gourami (*T. trichopterus*) was studied for 30 days using the above four OFF along with two commercial feeds *viz,* brine shrimp flake (T-5) and tubifex worm (T-6) (Table 15). The fish were fed at the level of 5% of their body weight.

Table 15. Growth performance of gourami *(T. trichopterus)* fed different feeds

Parameters	T-1	T-2	T-3	T-4	T-5	T-6
FCR	1.92^{b}	2.16^{a}	2.18^{a}	1.83^{b}	1.93^{b}	1.87
SGR	4.17^{abc}	3.52^{c}	3.66^{bc}	4.23^{ab}	4.10^{abc}	4.61^{a}
PER	1.30^{a}	1.16^{b}	1.14^{b}	1.34^{a}	1.28^{a}	1.32^{a}
PWG	210.79^{ab}	159.81^{c}	169.40^{bc}	214.51^{a}	206.79^{ab}	230.06^{a}
Cost of feed (Rs/kg)	88.75	58.70	226.30	147.85	1100.00	3500.00

Mean values with different superscripts in a row differe significantly (P<0.01).

It was concluded that the performance of blue gourami fed on feeds based on chicken liver meal and squid meal were similar (P>0.05) but the cost was higher in the later (Rs. 88.75 vs. 147.85/ kg).

Effect of different levels of *Spirulina* on the performance of *Cirrihinus mrigala* fry (*Subramanian and Mohanta, 2001-02*)

A feeding trial was conducted to find out the effect of different levels of *Spirulina* on the growth performance of *Chirrhinus mrigala* fry. The basal CSF was incorporated without (T-1) and with *Spirulina* @ 0.1 (T-2), 0.3 (T-3), 0.5 (T-4) and 1.0 (T-5) per cent levels. There were three replicates in each treatment. The mean weight of the carp fry was 1.75±0.20 g. The duration of the study was 60 days. The daily feeding rate was 5% of the body weight. The volume of water maintained was 100 L per container. The basal diet contained fish meal and ground nut oil cake at 30 per cent level each and had 40.27 per cent CP (Tables 16).

Table 16. Physical and chemical compositions of basal diet of *Cirrihinus mrigala* fry

Particulars	Percentage
Physical compositions	
Fish meal	30
Ground nut oil cake	30
Shrimp paste meal	10
Wheat bran	10
Maize powder	11
Wheat flour (binder)	5
Mineral and vitamin mixture	2
Vegetable oil	2
Chemical compositions (% DM basis)	
CP	40.27
EE	08.58
CF	03.20
TA	15.90
Moisture	10.20
Energy (kcal/g)	03.12

It was indicated that the feed formulated with 1% *Spirulina* had the best growth performances. However, there was significant difference in FCR and PER values indicating that *Spirulina* incorporation at 1% level was better than the other feeds (Table 17).

Table 17. Growth performance of *Cirrihinus mrigala* fry fed *Spirulina* incorporated feeds

Parameters	Experimental diets				
	T-1	T-2	T-3	T-4	T-5
PWG	125.49±5.42	159.28±4.86	142.81 ±7.49	158.03±15.29	168.13 ±17.42
FCR	3.24±0.1265^{a}	2.62±0.0819^{a}	2.99±0.1772^{a}	2.62±0.1987^{b}	2.52±0.1720^{b}
SGR	0.5883±0.0173	0.6889+0.0139	0.6416±0.0270	0.6850+0.0424	0.7124±0.0474
PER	0.7731±0.0276^{a}	0.9543+0.0309^{bc}	0.8386+0.0514^{ab}	0.9576+0.0740^{bc}	0.9953+0.0705^{c}
K	0.7758±0.0324	0.7994±0.0481	0.7536±0.0049	0.8224±0.0321	0.7376±0.0349

Means bearing different superscripts in a row differ significantly (P < 0.05).

It was concluded that *Spirulina* could be included in the diet of *Cirrihinus mrigala* fry without any adverse affect.

Effect of different levels of *Spirulina* on the performance of *Labeo rohita* fry (*Subramanian and Nirmale, 2002-03*)

Spirulina was incorporated in the basal diet **(**49-52% CP) of *Labeo rohita* fry at 0 (T-1), 0.5 (T-2), 1.0 (T-3), 3 (T-4), 5 (T-5) and 10 (T-6) percent levels. The physical and chemical compositions of the basal diet is provided in Table 18.

Table 18. Physical and chemical compositions of basal diet of *Labeo rohita* fry

Ingredients	Percentage
Physical compositions	
Fish meal	30
Groundnut oil cake	30
Shrimp paste meal	10
Wheat bran	10
Maize powder	11
Wheat flour (binder)	05
Mineral & vitamin mix.	02
Vegetable oil	02
Chemical compositions (% DM basis)	
CP	40.27
EE	8.58
CF	3.20
TA	15.90
Moisture	10.20
Energy (kcal/g)	3.12

A feeding trial with the above feeds was carried out on *Labeo rohita* fry. The mean weight of the fry was 0.87±0.23 g. The duration of the study was 60 days. The numbers of treatemnets were six with three replicates in each treatment. The numbers of rohu fry per replicate were 10. The feeding rate was 10% of the initial body weight. The volume of water maintained was 100 L.

Table 19. Growth performance of rohu fry fed diets with different levels of *Spirulina*

Treatments	PWG	FCR	SGR	PER	NPR
T-1	71.72	8.07	0.4014	0.2379	15.04
T-2	106.55	5.65	0.5518	0.3557	26.25
T-3	110.76	5.46	0.4904	0.3514	27.60
T-4	163.67	4.02	0.7012	0.5505	49.56
T-5	190.45	3.15	0.7714	0.6143	55.51
T-6	226.70	2.65	0.8573	0.7288	66.53
C.D (P=0.05)	22.41	0.70	NS	0.081	6.38

The results of all the growth performances incresaed progressively with the incresae in the level of *Spirulina* in the feed and remained maximum in T-6 (Table 19). It was concluded that *Spirulina* could be incorporated in the diet of *Labeo rohita* fry at 10 per cent level without hampering the growth performance.

Effect of different levels of beef liver on the performance of gold fish (*Carassius auratus*) (*Subramanian and Nirmale, 2002-03*)

Beef liver was tested as growth promoter on gold fish. Feeds were formulated with incorporation of beef liver in the basal diet of gold fish at the level of 0 (T-1), 5 (T-2), 10 (T-3), 15 (T-4), 20 (T-5) and 25 (T-6) percent levels. The mean weight of the fry was 1.65±0.12 g. The duration of the study was 30 days. The numbers of treatment were six with three replicates per treatment and 10 fish per replicate. The feeding rate was 10% of the initial body weight. The volume of water maintained was 100 L. It was observed that T-6 containing 25 per cent beef liver had higher weight gain, FCR, SGR and PER, compared to other diets (Table 20).

Table 20. Growth performance of gold fish (*C. auratus*) fed beef liver incorporated feeds

Treatments	PWG	FCR	SGR	PER
T-1	100.87	3.00	1.0109	0.2379
T-2	124.65	2.42	1.1704	0.3557
T-3	124.59	2.41	1.1710	0.514
T-4	129.40	2.34	1.1988	0.5505
T-5	136.08	2.22	1.2415	0.6143
T-6	141.17	2.15	1.2778	0.7288

It was concluded that beef liver could be incorporated in the diet of gold fish at 25 per cent level without hampering the growth performance.

Effect of feeding of different levels of beef liver on the performance of gold fish (*Carassius auratus*) (*Subramanian and Nirmale, 2003-04*)

Beef liver supplement was used as growth promoter by incorporating it in prestandardized carp basal feed by replacing fishmeal. The ingredient composition of the basal diet was fish meal 30, groundnut cake 30, shrimp paste meal 10, wheat bran 10, maize 11, wheat flour (binder) 5, mineral and vitamin mixture 2 and vegetable oil 2 parts by weight. Six experimental diets were prepared by replacing the fish meal of the basal diets by beef liver at the level of 0 (T-1), 5 (T-2), 10 (T-3), 15 (T-4), 20 (T-5) and 25 (T-6) per cent to study the effect of feeding of different levels of beef liver on the performance of gold fish. The CP% of T-1, T-2, T-3, T-4, T-5 and T-6 was 42, 46, 49, 47, 48, 49, percent respectively. The mean weight of the fry was 0.65±0.12 g. The duration of the study was 60 days. The numbers of treatments were six and the numbers of replicates were three per treatment with 10 fish per replicate. The feeding rate was 10% of the initial body weight. The volume of water maintained was 100 L. The percentage weight gain of T-6 with 25 per cent beef liver incorporation was 427.24 compared to that of T-1 having 236.12, over 60 days. Also, feed with 25 per cent beef liver incorporation had higher FCR, SGR, PER and NPR, which were 1.40, 1.2049, 1.4532 and 94.96, respectively (Table 21). There was a progressive incresing trend in the growth parameters from T-1 to T-6.

Table 21. Growth performance of gold fish (*C. auratus*) fed beef liver incorporated feeds

Treatments	PWG	FCR	SGR	PER	NPR
T-1	236.12	2.58	08757	0.9387	53.45
T-2	248.16	2.43	0.9022	0.9001	53.51
T-3	284.21	2.06	0.9908	1.0016	59.48
T-4	341.27	1.78	1.0499	1.2100	73.86
T-5	361.63	1.67	1.0901	1.2559	76.23
T-6	427.24	1.40	1.2049	1.4532	94.96
C.D (P=0.01)	94.762	0.624	0.188	0336	20.283

It was inferred that beef liver could be included in the diet of gold fish at the level of 25 per cent without any adverse effect on the growth performace.

Growth and nutrient utilization of rohu *(Labeo rohita)* fingerlings fed earthworm based diets (*Anonymous, 2005-06*)

Earthworm, which is a non-conventional protein source containing 52-53 per cent CP was used in three forms *viz.* (i) boiled (with a pinch of salt) and chopped (0.5 mm size) (ii) earthworm custard made up of earthworm (60%), skimmed milk powder (10%), hen's egg (22%), gelatin (6%) and mineral and vitamin (2%) and (iii) pelleted earthworm diet containing earthworm meal (40%), fish meal (10%), groundnut oil cake (30%), prawn meal (10%), gelatin (6%), mineral and viatamin. All the diets were made iso-protein (approx. 50% CP) and iso-caloric (5.0 kcal/g) and were fed to the rohu fingerlings (0.71$\pm$0.04 g). It was observed that the growth and nutrient utilization of fish fed pelleted earthworm diet was better ($p<0.05$) than the other diets. It was concluded that rohu *(L. rohita)* fingerlings could be reared on pelleted earthworm diet containing earthworm meal (40%), fish meal (10%), groundnut oil cake (30%), prawn meal (10%), gelatin (6%), mineral and vitamin.

Breeding and larval rearing of guppy (*Poecila reticulate*) (*Anonymous, 2006-07*)

Two experiments each of 30 days were conducted to study the breeding and larval rearing of guppy. The growth and breeding performance of guppy fed with combination of mosquito larvae and prepared diet were higher ($P<0.05$) than the fish fed with other two diets. Further, irrespective of indoor or outdoor rearing system, the growth and nutrient utilization were significantly higher in fish fed with combination of diets of Spirulina powder and brine shrimp larvae than the Spirulina powder and brine shrimp larvae alone. However, growth performance of outdoor rearing was higher ($P<0.05$) than the indoor rearing system.

Formulation of diets for blue gourami (*Trichogaster trichopterus)* using locally available ingredients (*Anonymous, 2006-07*)

Twelve locally available feed ingredients *viz.* snail meat, freshwater fish waste, surimi (fish paste), chicken waste, earthworm, squid, mussel, chicken liver, low-valued prawn, fish meal, groundnut oil cake and wheat bran were procured and analyzed to determine the proximate compositions. Nine diets with 35 per cent CP and 4.0 kcal/g GE were formulated using snail meat, freshwater fish waste, surimi by product waste, earthworm,

squid, mussel, chicken liver and lean prawn meal as major protein sources in addition to fish meal and groundnut oil cake and fed to blue gourami fingerlings in a closed water system. The fish fed with freshwater fish waste, surimi by-product, squid mussel, chicken liver and low-valued prawn meal based diets had higher ($P<0.05$) growth and nutrient utilization than the snail, chicken waste and earthworm based diets. It was concluded that freshwater fish waste and surimi by-product could be used as protein source in formulating cost effective diets for blue gourami.

Replacement of fish meal protein by surimi by-product protein in the diets for blue gourami (*Trichogaster trichopterus)* (*Anonymous, 2006-07*)

A study was conducted to replace the fish meal protein by surimi a by-product protein (a by-product of surimi processing plant) in the grower diets of blue gourami. Surimi by-product contains 52-56% CP. A fish meal based basal diet with 35% CP and 4.0 kcal/g GE was formulated in which the fish meal protein was replaced by surimi byproduct protein at 0 (control), 12.5, 25, 50, 75 and 100 per cent level and fed to blue gourami fingerlings (4.80$\pm$0.03 g) three times a day for a period of 45 days in a closed water system. Eighteen FRP tanks with 200 L of seasoned tap water were used for rearing the fish. No significant ($P<0.05$) variation was observed in weight gain, SGR, FCR and PER in fish, when the fish meal protein was replaced up to 50 per cent by surimi by-product protein. It was concluded that fish meal protein could be replaced up to 50 per cent level by surimi by-product protein without affecting the growth performance of blue gourami.

Grower diets for guppy (*Poecilia reticulate*) (*Anonymous, 2007-08*)

As per the nutrient requirements of guppy (*P. reticulate*), nine practical diets with 30 per cent CP, 10 per cent lipid and 4.0 kcal/g energy were formulated using snail meal, freshwater fish waster, surimi by-product waste, chicken waste, earthworm, squid, mussel, chicken liver and lean prawn meal as major protein sources in addition to fish meal and groundnut oil cake and fed to guppy fingerlings in a closed water system. Results indicated that the fish fed with squid meal, lean prawn meal, mussel meal and surimi by-product based diets had better ($P<0.05$) growth and nutrient utilization than the snail meal, freshwater fish waste, chicken waste, earthworm and chicken liver based diets in terms of growth rate, FCR and PER.

Effect of different sources of oil on growth and nutrient utilization of blue gourami (*Trichogaster trichopterus*) (*Anonymous, 2007-08*)

To evaluate the different sources of oil on growth and dietary performance of blue gourami, an experiment was conducted in which plant (soybean and sunflower) and animal (cod liver and surimi by-product) oils were used alone or in combination in the diet of fish. A basal diet containing 35 per cent CP and 4.0 kcal/g GE was prepared in which 8 per cent oil form different sources *viz.* sunflower oil (T-1), soybean oil (T-2), cod liver oil (T-3), surimi by-product oil (T-4), sunflower+cod liver oil (T-5) and sunflower+surimi by-product oils (T-6) were added as dietary lipids. Results indicated that the growth and dietary performance were better ($P<0.05$) in animal oil sources than the plant oil sources. Further, the combination of plant and animal oil sources resulted in better performance than the plant and animal oil sources used alone. It was concluded that the cod liver oil, which is traditionally used as animal oil sources in fish feed could be replace by surimi by-product oil in formulating the cost-effective diets for blue gourami.

Larval rearing of blue gourami (*Trichogaster trichopterus*) fed with prepared or live feeds (*Anonymous, 2007-08*)

The larvae of blue gourami were fed for a period of 60 days with five experimental diets *viz.* (i) prepared diets with 35% CP and 3.54 kcal/g GE; (ii) *Copepod*; (iii) *Artemia*; (iv) *Infusoria*; and (v) combination of all the above four diets. Results showed that the weight gain and SGR was higher ($P>0.05$) in larvae fed with *Artemia* and *Infusoria* than the larvae fed with prepared diets, *Copepod* and mixed diets. However, there was no difference ($P>0.05$) in weight gain and SGR of larvae fed with *Artemia* and *Infusoria*. It was concluded that *Infusoria* could replace the *Artemia* in larval rearing of blue gourami *(T. trichopterus)* without adversely affecting the growth of the larvae.

Development of practical diets for sword tail (*Xiphophorus hilleri*) (*Anonymous, 2008-09*)

Nine iso-proteinous (40% CP) diets were formulated using different conventional and non-conventional feed ingredients such as snail meal, freshwater water fish processing waste, marine fish processing waste, chicken waste, earthworm, squid meal, mussel meal, chicken liver, prawn meal as main protein sources in addition to fish meal and groundnut oil cake. The fish were fed thrice daily for a period of 60 days. For rearing the fish, flow-

trough FRP tanks with 100 L water were used. It was observed that the diet containing freshwater fish waste, snail and chicken liver as non-conventional protein sources had similar (P>0.05) results in terms of growth and nutrient utilization with the diets containing different conventional protein sources such as mussel meal, chicken liver, squid meal and prawn meal. It was concluded that non-conventional protein sources *viz*. freshwater fish waste, snail and chicken liver could be used for developing nutritionally balanced cost-effective practical diets for sword tail fingerlings.

Effect of feeding different forms of *Spirulina* to ornamental fish (*Anonymous, 2008-09*)
To study the effect of feeding Spirulina in different forms (wet and dry); blue gourami adults were fed with *Spirulina* based feeds and the growth performance was compared with the standard feed. The treatments were (i) wet *Spirulina* (ii) dry *Spirulina* incorporated feed and (iii) standard feed. It was concluded that wet *Spirulina* is a better maintenance adult feed for blue gourami (*T. trichopterus*).

Effect of feeding of Moina on the performance of ornamental fish (*Anonymous, 2007-08; Anonymous, 2008-09*)
An experiment was conducted by feeding young guppy (*Poecilia reticulata*) at 5% body weight with four treatments namely (i) *Moina,* (ii) *Artemia*, (iii) *Moina*+*Artemia* and (iv) standard formulated feed. It was observed that the growth performance with *Moina* and *Artemia* alone were similar and better than the formulated feeds and combination of *Moina*+*Artemia*. It was concluded that *Artemia*, a costly live feed could be replaced by cheaper *Moina* without adversely affecting the growth of blue guppy (*Poecilia reticulata*).

Further, feeding Moina to young guppy was studied with four treatments namely (i) standard feed, (ii) *Moina*, (iii) *Moina*+standard feed and (iv) *Moina*+*Spirulina* incorporated feed. Results indicated that live *Moina*+standard feed and *Moina*+*Spirulina* feed had better growth performance than *Moina* alone and standard feed. Guppy fed with *Moina* and *Spirulina* incorporated feed had maximum growth. It was concluded that that combination of live *Moina* and *Spirulina* could be good feed for weight gain in young guppy.

In another experiment, two size groups of Shubunkin gold fish were fed with *Spirulina* and *Moina* and their combinations with standard feeds (seven treatments). In the smaller sized group, combinations of *Spirulina*, *Moina* and standard feed performed better than *Moina* and *Spirulina* alone. With larger sized group the combination of *Spirulina*, *Moina* and standard feed had significantly higher growth, which was comparable to that fed with standard feed alone. The experiment indicated that the combination of *Spirulina* and *Moina* could be ideal source of all nutrients for the growth of gold fish.

Development of diets for black molly (*Poecilia latipinna*) (*Anonymous, 2009-10*)

Nine iso-proteinous diets with 40% CP were formulated using snail meal, freshwater fish waste, surimi by-product waste, chicken waste, earthworm, squid, mussel, chicken liver and lean prawn meal as major protein sources in addition to fish meal and groundnut oil cake. The maize and wheat bran were used as source of carbohydrate. The experimental fish were fed thrice daily in triplicate with 10 fish per triplicate (tank). The fish were reared in FRP tanks with 200 L of water in a closed water system. The excreta and the left over feed were removed through siphoning and the amount of water removed during the cleaning process were replenished again by seasoned well water. The tanks were cleaned every week and the water was exchanged fully on weekly basis. The growth performance of black molly (*Poecilia latipinna*) was better when fed diets with chicken liver and mussel meal as major protein sources than snail meal, freshwater fish waste, surimi by-product waste, earthworm, squid and lean prawn meal in addition to fish meal and groundnut oil cake.

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Salient research findings

Nutrient requirements for different fish

- The optimum protein and lipid requirements of blue gourami (*Trichogaster trichopterus*) fingerling were 35% and 8%, respectively.
- Blue gourami (*Trichogaster trichopterus*) fingerlings required 35 per cent protein, 8 per cent lipid and 40 per cent carbohydrate in the diet.
- The growth of blue gourami (*Trichogaster trichopterus*) fish fed on potato starch as carbohydrate source was maximum than the diets containing other sources (corn starch, wheat flour, tapioca powder and rice flour) of carbohydrate.
- The optimum Vitamin E requirement of blue gourami (*Trichogaster trichopterus*) brood stock was 150 mg/kg in diet for better growth and gonadal maturity.
- The guppy (*Poecillia reticulata*) fingerlings required 30 per cent protein and 10 per cent lipid in their diet.
- Sword tail (*Xiphophorus hilleri*) fingerlings required 40 per cent protein and 6 per cent lipid in their diet to attain maximum growth.
- Although the growth performance was better ($P<0.05$) in sword tail (*Xiphophorus hilleri*) fish supplemented with vitamin E at the level of 300 mg/kg diet, the breeding performance was better ($P<0.05$) at 400 mg/kg diet.
- Sword tail (*Xiphophorus hilleri*) fish fed 40% protein and 6% lipid had significant growth and nutrient utilization in terms of weight gain, specific growth rate, feed conversion ratio and protein efficiency ratio.
- Angel fish (*Petrophyllum scalare*) fed with 30 per cent protein and 6 per cent lipid had better ($P<0.05$) growth and nutrient utilization in terms of weight gain, specific growth rate, feed conversion ratio and protein efficiency ratio.

Feeds and feed ingredients for fish

- Chicken liver meal, prawn meal, squid meal, mussel meal and oyster meal had higher crude protein content, but were costlier and can be used for the ornamental fish feed formulation, wherein the feed requirement is less.
- *Spirulina platensis* and *Moina* can be used as feed for different types of fish.

Feed additives and supplements

- Probiotics containing *Lactobacillus spp.* @ 600 billion CFU/ kg could be supplemented at the level of 5 g/ kg in the diet of rohu (*Labeo rohita*) fry for higher growth performance.
- Enzyme-probiotics feed supplement could be supplemented at the level of 3 g/ kg in the diet of rohu (*Labeo rohita*) fry for higher growth performance.
- Yeast supplemented at the level of 5% in the diet of angel fish (*Petrophyllum scalare*) had higher growth performance.
- The guar gum based diet had higher growth performance of rohu (*Labeo rohita*) than the other binder supplemented diets.

Diet formulations for different fish

- Fish meal can be replaced 100 per cent by groundnut oil cake in the carp starter feed without hampering the growth performance of the carp fry (*Labeo rohita*).
- The animal protein source in starter carp feed could be replaced completely by plant protein source without affecting the growth performances of the carp fish.
- Though the formulated ornamental fish feeds (chicken liver based, prawn meal based, mussel meal based and squid meal based) had comparable growth performance in gold fish (*Carassius auratus*), they were much cheaper than the commercial feeds tested tubifex worm and brine shrimp flake).
- The performance of blue gourami (*Trichogaster trichopterus*) fed on feeds based on chicken liver meal and squid meal were similar ($P>0.05$) but the cost was higher in the later (Rs. 88.75 vs 147.85/ kg).
- *Spirulina* can be included in the diet of *Cirrihinus mrigala* fry without any adverse affect.

- *Spirulina* can be incorporated in the diet of *Labeo rohita* fry at 10 per cent level without hampering the growth performance.
- Beef liver could be incorporated in the diet of gold fish (*Carassius auratus*) at 25 per cent level without hampering the growth performance.
- Rohu (*Labeo rohita*) fingerlings can be reared on pelleted earthworm diet containing earthworm meal (40%), fish meal (10%), groundnut oil cake (30%), prawn meal (10%), gelatin (6%), mineral and vitamin.
- Freshwater fish waste and surimi by-product could be used as protein source in formulating cost effective diets for blue gourami (*Trichogaster trichopterus*).
- Fish meal protein could be replaced up to 50 per cent level by surimi by-product protein without affecting the growth performance of blue gourami (*Trichogaster trichopterus*).
- Guppy (*Poecilia reticulate*) fed with squid meal, lean prawn meal, mussel meal and surimi by-product based diets had better ($P<0.05$) growth and nutrient utilization than the snail meal, freshwater fish waste, chicken waste, earthworm and chicken liver based diets.
- Cod liver oil, which is traditionally used as animal oil sources in fish feed could be replace by surimi by-product oil in formulating the cost-effective diets for blue gourami (*Trichogaster trichopterus*).
- *Infusoria* could replace *Artemia* in larval rearing of blue gourami (*Trichogaster trichopterus*) without adversely affecting the growth of the larvae.
- Non-conventional protein sources viz. freshwater fish waste, snail and chicken liver could be used for developing nutritionally balanced cost-effective practical diets for sword tail (*Xiphophorus hilleri*) fingerlings.
- Wet *Spirulina* is a better maintenance adult feed for blue gourami (*Trichogaster trichopterus*).
- *Artemia*, a costly live feed can be replaced by cheaper *Moina* without adversely affecting the growth of guppy (*Poecilia reticulata*).

- Combination of live *Moina* and *Spirulina* can be a good feed for weight gain in young guppy (*Poecilia reticulata*).
- Combination of *Spirulina* and *Moina* is ideal source of all nutrients for the growth of gold fish (*Carassius auratus*).
- The growth performance of black molly (*Poecilia latipinna*) was better when fed diets with chicken liver and mussel meal as major protein sources than snail meal, freshwater fish waste, surimi by-product waste, earthworm, squid and lean prawn meal in addition to fish meal and groundnut oil cake.

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