Growth enhancement of carp and prawn through dietary sodium chloride supplementation

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Success in aquaculture depends to a great extent on sound nutritional practices based on the knowledge of nutrients required by the species cultured. It is estimated that the total feed cost in culture accounts for 30-70% of the production cost, depending upon the type of culture and the intensity of feeding[1]. There is a limit to the maximum growth rate beyond which further increment is possible only through genetic manipulation or administration of growth promoters that act pharmacologically to improve metabolic and / or digestive processes[2]. Supplementation of diets with growth inducing substances has the potential to be profitable because of the improved growth rate or reduced culture period. A wide range substances including hormones, antibiotics, nutrient mixtures and herbal products have been tested on farmed fish for their growth promoting potential when fed at graded levels. Varying levels of success have been reported. The fear of residues remaining in the end product is a serious issue with consumers and can result in restrictions being placed on access to export markets for entire nations.

Nearly 44% of the farmers in Andhra Pradesh, a southern state of India having the highest area under aquaculture, use common salt as an additive in fish feeds without really understanding its role in nutrition[3]. The use of common salt in aquaculture feeds is a regular practice in China also[4]. A few studies have been conducted to test the dietary role of sodium chloride, especially in the freshwater fish[5,6]. Freshwater fish take up salt from the surrounding water to maintain their osmotic balance, a process that consumes energy. Dietary supplementation of sodium chloride could be helpful in reducing the energy utilized for this purpose thus freeing energy that could be channeled into growth instead[7].

In order to study the influence of sodium chloride (common salt) on growth, body composition and digestive enzyme activity of carps and prawns, we carried out four separate experiments of 120-day duration each in 25m^3 (5x5x1m) outdoor cement tanks without soil base, at the College of Fisheries, Mangalore. We used the commonly cultured species-rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigaia*), common carp (*Cyprinus carpio*) and freshwater prawn *Macrobrachium rosenbergii* as test subjects. Diet (30% protein) consisting of fish meal (25%), groundnut cake (25%). rice bran (39%), tapioca flour (10%) and vitamin and mineral mixture (1%) was formulated[8] to which sodium chloride (E-Merck India Ltd.) was incorporated at graded levels of 0%, 0.5%, 1.0%, 1.5% and 2.0%. Fish of mean initial weight ranging from 0.56 to 1.60g (Table 1) stocked at 25 per tank (10,000/ha) and prawn of 1.1g stocked at 30 per tank. (12,000/ha) were fed the prepared diets once daily in the morning at 5% body weight. Feed quantity was readjusted every fortnight based on the weight recorded at each sampling. Water quality parameters like dissolved oxygen, pH temperature and total alkalinity were monitored at fortnightly intervals. On termination of the growth trials the activity of intestinal and hepatopancreatic protease, amylase and lipase was estimated and carcass proximate composition analyzed. A short-term study was also conducted to determine nutrient digestibility, using crude fiber as the marker for calculating apparent digestibility. The data generated for various parameters was subjected to analysis of variance (ANOVA), followed by Duncan's multiple range test[9].

The range of different water quality parameters monitored over the experimental duration was within tolerable limits for the species cultured. The levels of sodium chloride that induced the best growth differed with the species, it being 1% in rohu. 1.5% in mrigal and common carp and 2% in prawn (Table 1). Thus variation in response to sodium chloride was seen even within closely related fish species (carps). Higher weight gain with 2% sodium chloride supplementation was recorded in the eel Anguilla japonica[10] and juveniles of red drum[7,11]. Dietary salt is reported to influence growth by increasing food conversion efficiency in rainbow trout[12]. In our study, an improvement in food conversion and protein efficiency ratio was observed in the case of rohu and mrigal fed optimal level of dietary salt. Dosages above the optimum resulted in lower weight gain and food conversion in carps. Salt appears to affect growth rate inversely when the level of supplementation interferes with the balance of other essential dietary components. Further, low digestibility and faster evacuation of food have been associated with high levels of sodium chloride in diets[13].

Dietary salt also influenced body composition. Higher carcass protein and fat was recorded in sodium chloride fed rohu and common carp (Table 1). Increases in protein and fat content on feeding salt mixtures has been reported in rainbow trout and common carp[5,14]. Enhanced digestive enzyme activity was recorded in the

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Table 1: Major growth parameters observed in carps and prawn fed salt incorporated diets

Species/parameter	Salt level				
	0%	0.5%	1.0%	1.5%	2.0%
Rohu (*Labeo rohita*)					
Final mean weight (g)	51.12^{a}	62.50^{b}	75.69^{c}	56.96^{ab}	51.52^{a}
Weight gain over control (%)	-	22.26^{c}	48.06^{d}	11.42^{b}	0.78^{a}
FCR	1.77^{b}	1.56^{a}	1.47^{a}	1.79	1.85^{b}
PER	1.89^{a}	2.16^{ab}	2.29^{b}	1.88^{a}	1.82^{a}
Survival	88	88	84	88	86
Carcass protein (%)	13.03^{a}	14.30^{b}	14.99^{c}	14.99^{c}	14.08^{c}
Carcass fat (%)	7.24^{a}	8.45^{b}	10.13^{c}	9.73^{c}	7.95^{b}
Mrigal (*Cirrhinus mrigala*)					
Final mean weight (g)	57.28^{a}	69.69^{b}	78.46^{c}	95.7^{4}	70.91^{b}
Weight gain over control (%)	-	21.66^{a}	36.98^{b}	67.14^{c}	23.79^{a}
FCR	1.76^{d}	1.46^{c}	1.29^{b}	1.06^{a}	1.44^{c}
PER	1.88^{a}	2.30^{b}	2.59^{c}	3.17^{d}	2.38^{b}
Survival	90	88	92	88	94
Carcass protein (%)	14.84^{b}	16.72^{d}	15.69^{c}	15.31^{c}	13.92^{a}
Carcass fat (%)	5.25^{d}	3.26^{b}	3.03	3.71^{c}	2.15^{a}
Common carp (*Cyprinus carpio*)					
Final mean weight (g)	56.17^{a}	61.16^{b}	64.50^{bc}	68.81^{c}	66.86^{c}
Weight gain over control (%)	-	8.88^{a}	14.83^{b}	22.50^{d}	19.03^{c}
FCR	2.07^{b}	2.03^{ab}	2.00^{ab}	2.01^{ab}	1.93^{a}
PER	1.59^{a}	1.65^{a}	1.67^{a}	1.68^{a}	1.71^{a}
Survival	82	80	80	88	92
Carcass protein (%)	14.81^{a}	14.88^{a}	15.39^{b}	16.41^{c}	15.86^{b}
Carcass fat (%)	5.12^{a}	4.97^{a}	5.72^{b}	6.90^{d}	6.20^{c}
Freshwater prawn (*Macrobrachium rosenbergii*)					
Final mean weight (g)	23.55^{a}	24.33^{a}	27.05^{b}	31.76^{c}	36.83^{d}
Weight gain over control (%)	-	3.31^{a}	14.86^{b}	34.86^{c}	56.39^{d}
FCR	2.95^{c}	2.90^{c}	2.89^{c}	2.76^{b}	2.53^{a}
PER	1.13a	1.15^{b}	1.16	1.21^{c}	1.32^{d}
Survival	40	35	42	43	45
Carcass protein (%)	15.37^{a}	15.44^{a}	16.84^{b}	15.68^{a}	15.40^{a}
Carcass fat (%)	0.56^{a}	0.58^{a}	0.57^{a}	0.53	0.51^{a}
* The average initial weights of rohu, mrigal, common carp and prawn were 1.600, 1.20, 0.56 and 1.11g respectively Note: Figures in the same row with the same superscript are not significantly different (P>0.05)					

Table 2: Digestive enzyme activity* in the gut of carps and prawn fed salt incorporated diets

Species	Enzyme	Tissue	Salt level				
			0%	0.5%	1.0%	1.5%	2.0%
Rohu							
	Protease	Intestine	3.30^{a}	3.07^{c}	5.62^{d}	4.43^{b}	4.17^{b}
		Hepatopancreas	3.37^{b}	4.35^{c}	4.21^{c}	3.50^{b}	2.51^{a}
	Amylase	Intestine	14.33^{b}	15.82^{d}	16.59^{c}	13.98^{a}	15.00^{c}
		Hepatopancreas	11.83^{c}	12.17^{d}	12.46^{c}	11.60^{b}	11.12^{a}
	Lipase	Intestine	2.82^{a}	5.03^{b}	8.31^{c}	3.32^{a}	2.90^{a}
		Hepatopancreas	6.32^{b}	6.43^{b}	6.43^{b}	6.12^{b}	5.21^{a}
Mrigal							
	Protease	Intestine	1.02^{a}	1.51^{b}	3.06^{c}	1.95^{c}	2.32^{d}
		Hepatopancreas	2.84^{b}	1.66^{a}	1.91^{a}	3.04^{b}	3.61^{c}
	Amylase	Intestine	12.13^{a}	12.27^{a}	14.00^{b}	15.31^{b}	14.43^{b}
		Hepatopancreas	12.83^{a}	15.35^{c}	12.80^{ab}	15.02^{bc}	12.04^{a}
	Lipase	Intestine	2.38^{a}	2.23^{a}	2.61^{a}	2.54^{a}	2.62^{a}
		Hepatopancreas	2.14^{a}	2.33^{a}	3.00^{b}	4.51^{d}	4.00^{c}
Common carp							
	Protease	Intestine	16.62^{a}	21.71^{c}	23.07^{d}	24.22^{c}	19.31^{b}
		Hepatopancreas	23.06^{a}	22.12^{a}	21.97^{a}	26.87^{b}	22.34^{a}
	Amylase	Hepatopancreas	23.74^{a}	24.20^{a}	23.73^{a}	26.12^{ab}	28.45^{b}
		Intestine	32.16^{a}	33.45^{b}	33.12^{b}	33.32^{b}	44.56^{c}
	Lipase	Hepatopancreas	2.32^{a}	5.92^{b}	7.03^{c}	12.43^{c}	9.06^{d}
		Intestine	11.22^{b}	7.43^{a}	8.05^{a}	10.32^{b}	11.22^{b}
Prawn							
	Protease	Intestine	2.27^{a}	2.68^{a}	2.69^{a}	2.25^{a}	0.19^{a}
		Hepatopancreas	0.39^{a}	0.66^{b}	0.39^{ab}	1.32^{d}	0.92^{c}
	Amylase	Intestine	23.32^{a}	22.26^{a}	32.09^{c}	31.13^{c}	29.10^{b}
		Hepatopancreas	9.71^{a}	11.80^{b}	12.63^{c}	13.46^{d}	16.41^{c}
	Lipase	Intestine	0.84^{a}	2.10^{b}	4.10^{c}	4.90^{d}	4.10^{c}
		Hepatopancreas	0.40^{a}	0.61^{b}	0.78^{c}	0.31^{a}	1.19^{d}
* Enzyme activity expressed as u miles of product liberated/minute/10mg tissue protein at 28C Figures in the same row with same superscript are not significantly different (P>0.05)							

Shrimp pond maintenance. Photo: U Win Latt

urea, ammonium sulfate and calcium ammonium nitrate. Among these, urea is suitable for slightly acidic to neutral soil, ammonium sulfate for alkaline soil and calcium ammonium nitrate for acidic soil. Depending on the available nitrogen content of the pond soil, application of 50-70 kg nitrogen/ha (i.e. 108-152 kg urea/ha; 200-280 kg calcium ammonium nitrate/ha; 250-3 50 kg ammonium sulfate (ha) in rearing ponds and 75-150 kg/ha/year (i.e. 163-326 kg urea /ha/year; 300-600 kg calcium ammonium nitrate /ha/year; 375-750 kg ammonium sulfate/ha/year) in stocking ponds give good results. The fertilizer should be applied in equal monthly splits alternately with organic manure with a gap of about a fortnight.

Single Super Phosphate (SSP) is most commonly used as a phosphate fertilizer in fish ponds. Depending on the available phosphate content of pond soil, application of 25-50 kg phosphate (P2O5) /ha (i.e. 156-312 kg SSP/ha) and 40-75 kg P205/ha/year (i.e. 250-468 kg SSP/ha) in rearing and stocking ponds, respectively give good results. To get better utilization efficiency, phosphorus fertilizers should be applied in weekly intervals and the first installment should be given seven days after initial organic manuring.

Muriate of potash (potassium chloride, KCl) and sulfate of potash (potassium sulfate, K2S04) are commonly used as potassium fertilizers in fish ponds. Application of 10-20 kg K20/ha (i.e. 16-32 kg KCl/ha or 20-40 kg K2S04/ha) and 25-40 kg K20/ha/year (i.e. 41-66 kg KCl/ha or 52-83 kg K2S04/ ha/year) in rearing and stocking ponds, respectively give good results. The fertilizer should be applied in equal monthly splits.

Application of manure and fertilizer should be suspended if thick green or blue green blooms of algae develop in the pond in order to avoid depletion of oxygen.

Careful use of organic manures and chemical fertilizers in combination is a sound strategy. Occasional development of un-hygenic conditions in the pond may be avoided by using pre-decomposed organic manure. Use of excessive amounts of raw organic manure can result in excessive blooms of microbes during aerobic breakdown of large amount of raw organic manure, and may also caused oxygen depletion.

An understanding of chemical and biological conditions of pond soil and water through regular monitoring systems and adoption of efficient and careful management practices will lead to enhanced production of fish food organisms and thereby increase the growth and survival of fish.

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intestine and hepatopancreas of the treated fish as well as prawn (Table 2). The type of diet is known to influence the activity of digestive enzymes[15]). Increased digestive enzyme activity coupled with higher nutrient digestibility might have been responsible for better utilization of nutrients from salt incorporated diets.

Our results suggest that dietary inclusion of salt can be beneficial.

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