

EFFECT OF CARBOHYDRATE (STARCH) LEVEL IN PURIFIED DIETS ON THE GROWTH OF *PENAEUS INDICUS*

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ABSTRACT

Four purified diets were formulated using casein, gelatin, starch, fish oil, groundnut oil, vitamins, minerals and cellulose. The carbohydrate in the diets was increased from 10 to 40% by varying the starch content to study the effect of dietary carbohydrate level on the growth, survival and food conversion of the prawn *Penaeus indicus*. The protein and the lipid contents were kept constant in all the diets. Feeding experiments conducted in the laboratory on the juvenile *P. indicus* indicated that the growth of prawn increased with increase in the dietary carbohydrate level from 10 to 40% ($P < 0.01$). The food-conversion efficiency and the rate of survival improved with the increase of carbohydrate level in the diet. The growth also increased with the increase of carbohydrate calorie ratio, while it was better with lower protein carbohydrate ratio of the diets.

INTRODUCTION

Carbohydrate is a cheap source of energy in the diet of animals, including fish and prawns. If a large percentage of the metabolic energy requirements of the animal can be met from the carbohydrate, the more expensive protein can be spared for growth. The protein sparing action of the carbohydrate in the diet at 30% level was reported by Andrews et al (1972) in *Penaeus aztecus*. Sick and Andrews (1973) found that 40% corn starch in casein-based diets produced faster growth in *P. duorarum*. The carbohydrate requirements of the Indian white prawn *P. indicus* are not known. With a view to finding out the effect of dietary carbohydrate level on the growth and food conversion of *P. indicus*, the present study had been carried out. Since Abdel Rahiman et al (1979) had reported that the polysaccharides like starch, dextrin and glycogen gave better growth, along with disaccharides, in *P. japonicus*, starch was selected as the source of carbohydrate in the present study.

MATERIAL AND METHODS

Fat-free casein was obtained from Centron Laboratories, Bombay. Gelatin used in the diets was obtained from B.D.H., and starch from Merck. Sardine oil and refined groundnut oil were locally purchased. The vitamin mixture was obtained from Roche Pharmaceuticals; the mineral mixture was prepared in the laboratory. Cellulose powder was procured from Johnson Chemicals, Bombay.

Preparation of the diets

Four purified diets (C1, C2, C3 and C4) were formulated using casein, gelatin, starch, a mixture of sardine oil and refined groundnut oil (in ratio 1 : 1). The starch content was varied from 10 to 40% in the diets C1 to C4. Cellulose powder was used as the non-nutrient filler. Vitamins and minerals were included in all the feeds. No extra binding material was used since all the diets contained gelatin and starch. The protein content in all the diets was kept approximately at 35%. By virtue of variation in the carbohydrate content, the protein carbohydrate ratio varied from 3.5 to 0.92 in the diets from C1 to C4 while the carbohydrate calorie ratio changed from 2.079 to 8.831. The percentage composition of the diets is given in table 1.

The starch and the gelatin were dissolved in 80 ml (for 100 g of diet) of water and cooked into a paste, while the other ingredients were separately

TABLE 1. *Percentage composition of the diets.*

Ingredients %	Diets			
	C ₁	C ₂	C ₃	C ₄
Casein	30	30	30	30
Gelatin	06	06	06	06
Oil *	06	06	06	06
Starch	10	20	30	40
Vitamin and mineral (mix **)	03	03	03	03
Cellulose powder	45	35	25	15
Total	100	100	100	100
<i>Proximate composition % on dry basis</i>				
Crude protein	35.75	33.25	37.62	36.75
Lipid	6.00	6.00	6.00	6.00
Carbohydrate (Starch)	10.0	20.0	30.0	40.0
Ash	4.0	4.25	4.03	6.25
Calorific value (K cal/g)	4.81	4.79	4.66	4.53
Protein carbohydrate ratio	3.50	1.75	1.25	0.92
Carbohydrate calorie ratio	2.079	4.166	6.437	8.831

* The oil used consists of a mixture of fish oil (Sardine) and groundnut oil in the ratio 1 : 1.

** The mineral and vitamin mixture : Every 500 g consists of Vitamin A 6,25,000 I.U; Vitamin D³, 62,500 I.U; Vitamin E, 250 I.U; Vitamin B₂, 200 mg, Calcium, 126.0 g; Phosphorous, 90.0 g, Copper, 1.25 g, Iodin as iodate, 0.25 g, Manganese 1.00 g, Cobalt 0.10 g and Zinc 0.50 g.

powdered and passed through a 30-mesh sieve and added to the paste. The mixture was then thoroughly homogenised and passed through a 3mm-diameter extruder. The extruded part was dried in an electric oven at $65 \pm 2^\circ$ for 12 h, and stored in air tight plastic containers until use as diet.

The crude protein of the diet was determined by Kjeldahl method and the calorific value was determined using bomb calorimeter.

Feeding experiments

Juveniles of *P. indicus* from the same brood, reared in the prawn culture laboratory of CMFRI, Narakal, were randomly selected and used in the experiments. The average initial length was about 27 mm and weight 0.1 g.

The animals were stocked in 3'-diameter collapsable plastic pools with 300 l sea water, filtered through boltingsilk. In each pool, 20 animals were kept, with two replicates for each treatment. Aeration was provided intermittently in all the pools. The water in the pools was changed every six days.

Feeding was done at the rate of 25% of the body weight per day, to start with. But subsequently, feeding was adjusted, to 15 to 10% of the body weight per day, according to the left over food. Feeding was done once a day, in the evening. The feeding experiment was carried out for a period of 30 days.

The salinity of the water was maintained at $16 \pm 1\%$ throughout the experiment. The temperature ranged between 26°C to 27°C and the pH of the water varied from 7.9 to 8.0 during the experimental period.

RESULTS

The results of the feeding experiment are presented in table 2. It can be seen that the growth of the prawns, both in length and weight, gradually increased (from 62.3% to 147.6%) with the successive increase in the carbohydrate level of the diets. The diet with 40% starch recorded the highest growth (fig. 1 curves A and B). The food conversion efficiency improved with the increase in the dietary carbohydrate level up to 30%. There is a slight decline thereafter. The percentage of survival is maximum (95%) at 40% carbohydrate level.

The experimental data were subjected to statistical analysis and were analysed by the method of analysis of non-orthogonal data by fitting constants. For this, the model used was:

$$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$$

Where Y_{ijk} is the length of the K^{th} individual in the j^{th} replicate of the i^{th} diet level.

a_i = the effect of i^{th} diet level.

b_j = the effect of j^{th} replicate.

$(ab)_{ij}$ = the interaction effect.

e_{ijk} = random error component.

The analysis is summarised in table 3. It can be seen that the interaction is highly significant along the treatments and replications, indicating that treatments and replicates are not independent. That is, there is a differential response to treatments over the replications and vice versa. From individual mean composition, it is observed that treatments significantly differ among themselves, diets C3 and C4 scoring over C1 and C2. Thus there is increase in growth with the increase in carbohydrate level in the diet ($P < 0.01$) from C1 to C4.

The results also indicate that the low protein carbohydrate ratio and high carbohydrate calorie ratio produce higher growth rates (Fig. 2. curves C, D, E, and F) and survival and improve the food conversion efficiency of the diet.

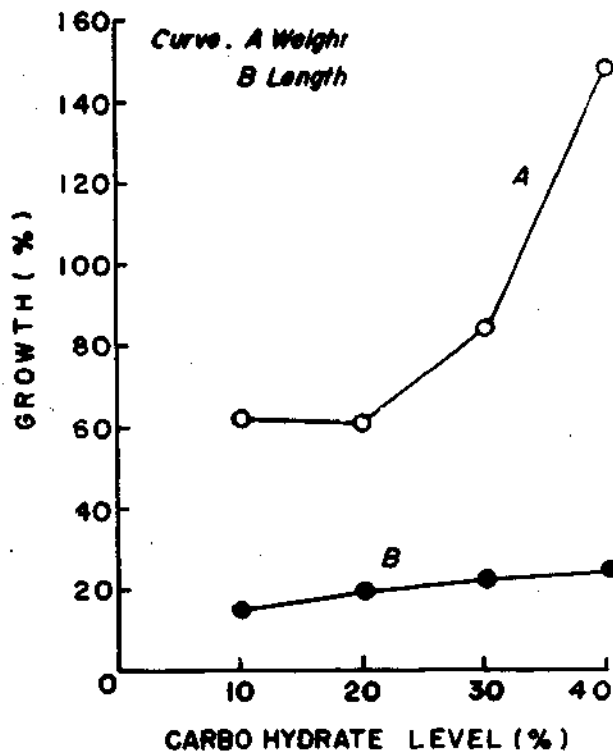


FIG. 1. Relationship between the dietary carbohydrate level and growth

TABLE 2. Data on the feeding experiment with feeds C1 to C4 on *P. indicus* for 30 days.

	Diets			
	C ₁	C ₂	C ₃	C ₄
Initial mean length (mm)	27.05	27.37	27.40	27.87
Initial average weight (g)	0.105	0.105	0.105	0.105
Final mean length (mm)	31.01	32.68	33.43	34.62
Final average weight (g)	0.170	0.169	0.193	0.260
Percentage increase in length	14.70	19.30	21.90	24.30
Percentage increase in weight	62.30	61.0	84.20	147.60
Percentage survival	72.5	87.5	82.5	95.0
Food conversion*	11.15	5.55	4.07	4.25

$$* \text{ Food conversion} = \frac{\text{Weight of food consumed}}{\text{live weight gain}}$$

TABLE 3. Statistical analysis : ANOVA

Source	Degrees of freedom	Sum of squares S.S.	Mean square
Feed levels	3	233.5612	77.8537 X X
Replicate	1	14.9718	14.9718 X X
Treatments	3	187.8687	62.6226 X X
Errors	129	811.3187	6.2893

X X = Highly significant ($P < 0.01$)

DISCUSSION

The increase in the carbohydrate level in the diets enhanced the growth in prawns. This may be due to the protein sparing action of carbohydrate in which the increased levels of carbohydrate in the diet might have provided larger quantum of energy required for the metabolic activities of the animals, while more and more protein had been spared for growth. The enhanced growth at higher levels of carbohydrate might be responsible for better food conversion values. At the lower levels of carbohydrate in the diet, the animals might be deriving the metabolic energy partly from protein, thus accounting for lesser growth even though the protein and lipid levels in the diets at lower and higher carbohydrate levels were the same.

The diet with 40% carbohydrate produced the highest growth which is maximum level tested. Andrews et al (1972) have reported that 30% starch in the diet gave better growth and spared protein in the diet in *P. aztecus*. Sick and

Curves — C & E Weight

Curves — D & F Length

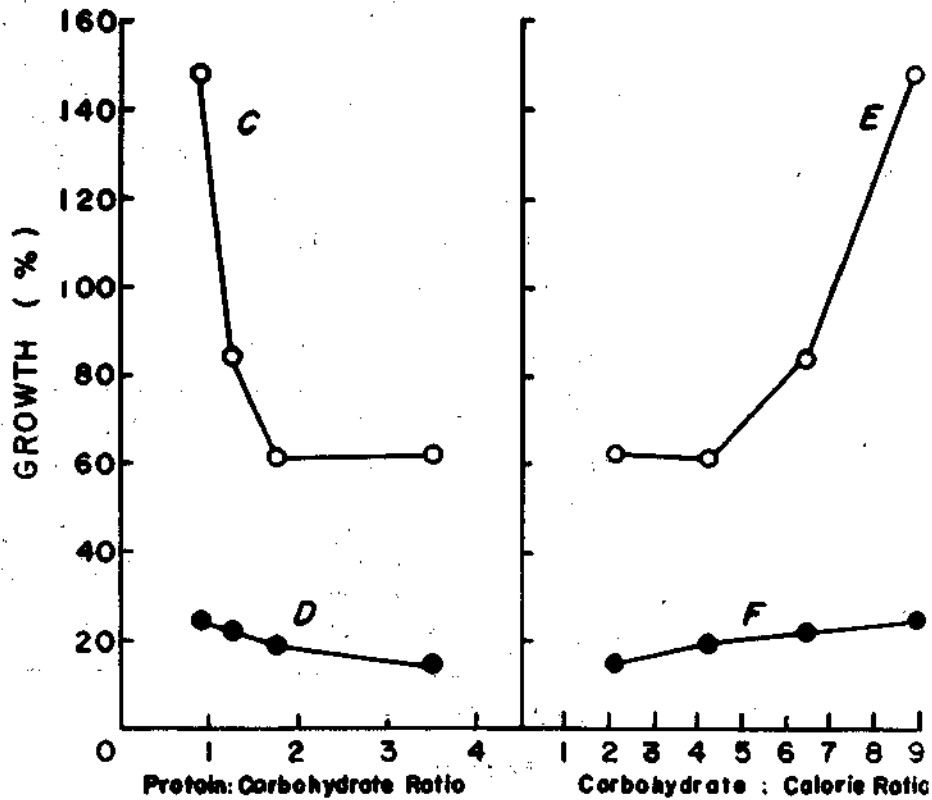


FIG. 2. Relationship between growth, protein-carbohydrate ratio and carbohydrate-calorie ratio

Andrews (1973) found that 40% corn starch in the casein-based diets produced faster growth in *P. duorarum*. The results obtained in the present study on *P. indicus* are in agreement with these findings.

The performance of the diet can be improved by reducing the protein carbohydrate ratio. As indicated in the present study (Fig. 2 curves C and D), it can be less than unity. That is, the carbohydrate level in the diet can be as much as that of the protein or even more. The growth of prawns also gradually

increased with the increase in carbohydrate calorie ratio (Fig. 2 curves E and F). These relationships indicate that by increasing the carbohydrate level (up to 40%) in the diet, the protein can be spared and the calorific value of the diet can be maintained and thus improve the overall performance of the diet.

The growth of prawns obtained with purified diets in the present study (147.6%) is low compared to the growth obtained in the laboratory experiments in *P. indicus* (413% to 690%), with feeds compounded with natural ingredients reported earlier by the author (Ahmad Ali 1980). Similar inferior growth was reported in prawns with purified diets prepared using casein, amino acid, mixtures and peptides by Kanazawa, et al (1970), Sick et al (1972) and Deshimaru and Kuroki (1974 c, 1975 a and b).

The use of cellulose powder as a non-nutrient filler in purified diets appears to affect the palatability of the diets for prawns in the present study. The maximum levels of cellulose that can be used in the purified diets without affecting the palatability needs further investigation.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. E. G. Silas, Director, OMFRI, Cochin, for the encouragement during this work. Sincere thanks are due to Sri. K. H. Mahamed for critically going through the manuscript. Thanks are also due to Sri S. Srinath for helping in the statistical analysis.

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