

FORMULATION OF CHEAPER ARTIFICIAL FEEDS FOR SHRIMP CULTURE: PRELIMINARY BIOCHEMICAL, PHYSICAL AND BIOLOGICAL EVALUATION

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ABSTRACT

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A compound shrimp diet was prepared making use of the locally available natural food stuffs, slaughter house products and factory by-products. The ingredients, viz: beef liver (discarded for human use on veterinary grounds), coconut oil cake, soya flour, mangrove leaves, and wheat flour, were analysed biochemically for their nutritive value. The formulated diet is in a dry pellet form. It was assessed experimentally for its physical stability and subsequently fed to various size groups of a palaeomonid prawn (*Leptocarpus potamiscus*) for biological evaluation. The results of the investigations suggest that beef liver meal and coconut oil cake are rich in protein and can be utilized in the formulation of aquatic diets. The diet is highly water stable, consumable and assimilable. It should be tested upon both palaeomonid and penaeid prawns in further experiments.

INTRODUCTION

Prawn culture has, since ancient times, been practised in paddy fields and low lying areas adjacent to backwaters in India. However, to date, the methods used have included only simple stocking and growing of the juveniles to the adult stage without giving any additional foods. Qasim (1975) commented that the present yield of 500–1500 kg ha⁻¹ year⁻¹ from these culture operations can be improved to 2500 kg ha⁻¹ year⁻¹ by giving artificial supplementary feeds. The conventional food stuffs used for feeding the prawns in most western countries are clam meat, and fish and squid meals, which are financially far beyond the reach of the average Indian fish farmer. Since the feeds comprise one of the largest items in the recurring expenditure of a shrimp farm, it is highly desirable to develop cheaper prawn diets so as to make prawn culture a profitable venture.

In the present study, a compound shrimp diet was prepared in the laboratory by utilizing the locally available natural raw materials, animal wastes

and factory by-products. The finished product is in a dry pellet form. Keeping the criteria of a good shrimp diet in view (Goodwin and Hanson, 1975), the ingredients were evaluated chemically for their nutritional value, and the finished form was assessed for its physical stability in sea water. Further, the diet was fed to various size-groups of a palaeomonid prawn, and the percent survival, growth and food conversion efficiency were recorded. The results of these preliminary investigations to assess the suitability of the prepared feed as a shrimp diet for future experiments are given and discussed in this paper.

MATERIAL AND METHODS

Composition and preparation of the feed

The shrimp diet was composed of slaughter house products, viz: beef liver, discarded for human use (IF₁), coconut oil cake (IF₂), soya flour (IF₃), mangrove leaves (IF₄) and wheat flour (IF₅), in the percentages given in Table I. The details of preparing the feed are described by Balazs et al. (1973). The final product was labelled FN-1.

TABLE I

Percent values of protein, carbohydrate and lipids in various ingredients of the formulated diet FN-1 (calculated on dry weight basis)

Ingredients*:	IF ₁	IF ₂	IF ₃	IF ₄	IF ₅
Protein (%)	62.75	36.43	26.50	17.18	13.25
Carbohydrate (%)	3.5	12.0	8.0	15.5	29.5
Lipid (%)	12.0	12.2	22.0	36.0	8.0

*IF₁ = slaughter house product; IF₂ = coconut oilcake; IF₃ = soya flour; IF₄ = mangrove leaves; and IF₅ = wheat flour.

Biochemical analysis

Biochemical investigations were performed on all the ingredients of the diet in order to see their nutritive value and to formulate feeds with different dietary levels of protein, carbohydrate and lipids at a later stage. The techniques applied for analysing the above-mentioned components of nutrition were the same as those of Johnson (1941), Dubais et al. (1956) and Bligh and Dyer (1959), respectively. The percent values are given in Table I. The amounts of these nutrients in the finished form of the feed were calculated on the basis of the dry weights of the individual ingredient used, and are shown in Table II.

TABLE II

Composition (%) of different ingredients of diet FN-1, and the proportions (%) in which they are present in diet FN-1 (calculated on dry weight basis)

Ingredient	Proportion in diet (%)	Composition		
		Protein (%)	Carbohydrate (%)	Lipid (%)
Slaughter house waste (beef liver meal):	(IF ₁) 21	13.18	0.74	2.52
Coconut oil cake:	(IF ₂) 13	4.74	0.13	0.13
Soya flour:	(IF ₃) 21	5.57	1.68	4.62
Mangrove leaves:	(IF ₄) 6	1.03	0.93	2.16
Wheat flour:	(IF ₅) 39	5.18	11.50	3.12
Distilled water:	37.5	—	—	—
	Total	29.70	14.98	12.55

Physical evaluation

Two experiments were designed to find out the adhesive properties of different binders with varying sizes of food particles, and the water stability of diet FN-1 at different salinities.

For experimental purposes, four more feeds were prepared following the methods described for FN-1; the only difference being that component IF₅ of FN-1 (wheat flour), which also acted as a binder, was replaced by fine wheat flour (maida), pure starch, gum acacia and gram flour. These diets were labelled FN-2, FN-3, FN-4 and FN-5, respectively. Four sizes of food particles with varying length and breadth ratio were selected (2 × 80 mm, 1 × 40 mm, 8 × 8 mm and 2 × 3 mm), and these are mentioned as a, b, c and d in the tabulated data. The feeds were added to glass beakers containing 1 l sea water of salinity 10 ± 2‰. No aeration was given. Readings for buoyancy and consistency of the diet were recorded within a period of 48 h (Table III). Replicate experiments were conducted.

In experiment 2, a weighed amount of formulated diet FN-1 was added to the two sets of eight replicate 45 × 23 × 30-cm tanks containing sea water of 0, 5, 10, 15, 20, 25, 30 and 35‰ salinity. The other environmental parameters, viz: depth of water (12 cm), temperature (30 ± 1°C), aeration (30-50 bubbles/s) and photoperiod (12 h), were kept uniform. The experiment was run for 24 h; at the end of which, the dry weight loss of the diet was measured following Balazs et al. (1973). The readings are given in Table IV.

TABLE III

Binding capability test on five feeds (FN-1 to FN-5) containing different binders with a, b, c and d-sized food particles (salinity of water 10‰)

Time (h)	FN-1				FN-2				FN-3				FN-4				FN-5			
	a*	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
0.0	SI**	F	F	SI	SI	F	F	F	F	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI
0.05	SI	F	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
0.20	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
0.50	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
1.20	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
1.50	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
1.80	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
2.10	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
2.40	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
3.10	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
3.40	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
4.10	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
4.40	SI	SI	SI	SI	SI	F	F	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
24.0	SI	SI	SI	SI	SI	FB	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI
48.0	SI	SI	SI	SI	SI	-	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI

*Food particle size: a, 2 × 80 mm; b, 1 × 40 mm; c, 8 × 8 mm; d, 2 × 3 mm.

**S, settled down; I, intact; F, floating; B, broken on touch.

TABLE IV

Percent dry weight loss of the formulated diet FN-1 in different salinities kept for 24 h

Salinity (‰):	0	5*	10	15	20	25	30	35
Mean initial weight (mg)	37	35	39	34	30	30	36	31
Mean final weight (mg)	37	34	39	34	30	30	36	31
% Weight loss	—	2.86	—	—	—	—	—	—

* At this salinity, the food was broken while pipetting it out.

Biological evaluation

To assess the suitability of the diet as a prawn feed, preliminary feeding experiments were carried out on a palaemonid prawn, *Leptocarpus potamiscus*, collected from the mangrove swamps near Borim bridge, Goa. The experiments were conducted in four sets, with varying size groups of animals. The average length of animals in group numbers 1, 2, 3 and 4 was 17.4, 19.0, 26.13 and 27.46 mm, respectively. Each set and its replicate consisted of 15 animals, kept in a 45 × 23 × 30-cm glass tank containing sea water of salinity 10 ± 2 ‰. The other environmental factors were similar to those in experiment 2. The studies were carried out for 15 days. The methods of feeding the animals, collecting and computing the data are as given by Royan et al. (1977).

RESULTS

Binding efficiency and water stability

The results of experiment 1, performed to compare the binding capabilities of different binders while using different sizes of food particle, showed that wheat flour, used as binder in FN-1, was the most efficient of all, as all sizes of food particle settled down immediately and remained intact even when pipetted out after 48 h (Table III). With the present composition of the diet, gum acacia and gram flour were the most unsuitable since all sizes of food particle disintegrated within 20 min of the start of the experiment. The remaining two feeds, FN-2 and FN-3, with maida and starch, respectively, as binders were also quite good, though size b of FN-2 and sizes c and d of FN-3 were not suitable for very long periods.

The second experiment, which was carried out to test the water stability of the feed (FN-1) in sea water of different salinities, showed that this feed was stable at all concentrations (Table IV). The loss recorded at 5‰ salinity was actually due to mishandling of the diet while pipetting it out.

Nutritive value

Biochemical analysis showed that the items selected for the present feed, in addition to being cheaper, possessed all the major components of nutrition. The percent values are shown in Table I. Thus, the compound form of the diet had the advantage of having a multi-protein, carbohydrate and lipid composition which has been considered more suitable by earlier workers. Slaughter house products added the major portion of protein, wheat flour of carbohydrate and soya flour of the lipids (Table II).

Biological evaluation of the diet

The results of the four sets of feeding experiments performed on different size groups of prawn *Leptocarpus potamiscus* showed that all the animals survived till the last day of the experiment (100% survival). They gained weight, fed well and were active and healthy. Most of them molted once. However, a consistent decrease in the values of growth rate, consumption of food/unit wt. per day, and assimilation and conversion efficiencies with an increase in the size of the animals was noticed. For example, the smaller prawns ($W = 0.012$ g) consumed more (0.261 g), assimilated almost all food ($A/C = 98.51\%$) and converted a substantial portion of it into body tissue ($K_1 = 27.66\%$ and $K_2 = 28.08\%$). The next larger group, with slightly higher mean weight (0.015 g), showed a marked reduction in consumption/unit wt. per day (0.175 g), but still assimilated well ($A/C = 94.93\%$), and converted the food efficiently ($K_1 = 24.19\%$, $K_2 = 24.26\%$). The food utilization in these two groups was distinctly different from the next two groups with higher mean weights (0.036 and 0.040 g). The latter two groups consumed only slightly less than the second group of animals, but showed a lower efficiency of assimilation and much lower efficiency of conversion (Table V). The last group, with the largest sized animals, had a conversion efficiency at least 10 times lower than that of the first group.

TABLE V

Food conversion efficiency of shrimps fed on the formulated diet FN-1 (values in dry wt (g) /animal, and experimental period was 15 days)

Group No.	Initial weight W_1	Final weight W_2	Mean weight W	Production $P=W_2-W_1$	Relative growth rate/day $P/W/15$	Food consumed C	Faecal output F
1	0.005	0.018	0.012	0.013	0.072	0.047	0.0007
2	0.010	0.019	0.015	0.009	0.040	0.0395	0.002
3	0.033	0.038	0.036	0.005	0.009	0.0847	0.0089
4	0.039	0.041	0.040	0.002	0.003	0.085	0.0095

DISCUSSION

A review of the earlier literature suggests that the efficiency and suitability of a shrimp diet depend upon different factors like composition of the diet, water stability, palatability and conversion efficiencies (Goodwin and Hanson, 1975; New, 1976).

The omnivorous nature of most prawns had led various workers to try different compositions of prawn feeds in a continuous effort to prepare economically feasible diets. Kanazawa et al. (1970) prepared a purely chemically based diet approaching the biochemical combination of clam meat, but found the latter comparatively more effective. Sick et al. (1972) added one or more natural food stuffs to the above-mentioned purified diets and found that semipurified diets gave better results. Stern et al. (1976) tried pure plant diets alone and in combination, and reported mixed feeds to be more suitable. Balazs et al. (1974) and Balazs and Ross (1976) used multi-protein diets containing plant and animal protein and described them producing good growth. Venkatramiah et al. (1975) reported that the presence of vegetable matter enhanced the food conversion efficiency of the diet in *P. aztecus*.

Keeping in view the importance of the various components of the diet as reported by these workers, and local availability of the cheaper representative materials, the present shrimp diet was formulated. Slaughter house products contributed the animal protein content, soya flour, wheat flour and coconut oil cake the plant protein, carbohydrate and lipid contents, and the mangrove leaves the vegetable matter content. Earlier, Ghittino (1972) had reported the use of selected slaughter house by-products (spleen, liver, etc.) as supplementary wet diets in the culture of salmonid fish. Jhingran and Gopalakrishnan (1973) used mustard oil cake as supplementary feed in the monoculture of mullets. Qasim (1975) described the use of oil cakes as direct manure in polyculture ponds of fish and prawns in many south-east Asian countries. However, this investigation is the first time all of these food items have been tried in a compound form.

Assimilation $A=C-F$	Metabolism $R=A-P$	Assimilation efficiency $A/C\%$	Gross growth efficiency $K_1=P/C\%$	Net growth efficiency $K_2=P/A\%$	Consumption/unit wt/day $C/W/15$
0.0463	0.033	98.51	27.66	28.08	0.261
0.0375	0.028	94.93	24.19	24.26	0.175
0.0758	0.071	89.49	5.90	6.60	0.157
0.0755	0.009	88.82	2.35	2.65	0.141

The results of the experiments done for physical evaluation of the pellet form suggest that the present composition of the diet can be used effectively in formulations of varying sizes of the pellet depending upon the need of the experimental animals. It was further ascertained that the diet can be tested with both penaeid and non-penaeid prawns since it withstands a wide range of salinities. The investigation confirms the good binding capacity of the wheat flour earlier described by Hysmith et al. (1972) and Balazs et al. (1973).

Biological evaluation tests performed in this investigation indicated that the feed is in a consumable and highly assimilable form. However, further modifications of the percentage compositions of various components of nutrition on the dietary level are necessary.

In conclusion it may be said that the cheap raw materials selected for use in the diet had good nutritive values and should be tried in different compositions in future experiments. The diet in its present form has all the basic qualities of a shrimp diet and can be tested upon juveniles of economically important species of both penaeid and palaeomonid prawns.

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