J. mar. biol. Ass. India, 2000, **42** (1&2) : 62 - 73

Suitability of different binders in feed formulation for *Penaeus indicus*

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Abstract

Feeds were formulated using different binders like agar agar, sodium alginate, gelatin, tapioca flour, carboxy methyl cellulose, carageenan, potato starch, guar gum, polyvinyl alcohol, starch powder, neem gum and chitin powder at varied levels. The visual water stability and percentage weight loss of the prepared feeds were assessed. The effect of these feeds on growth parameters were also assessed. The feed incorporating 4% guar gum gave highest growth. The performance of the feed was also tested at field levels. Growout studies conducted with feed incorporating 4% guar gum as a binder showed good water stability and growth in *Penaeus indicus*.

Introduction

The water stability of an aquatic feed plays an important role in determining the overall performance of the feed. Feed that disintegrate faster facilitate rapid leaching of nutrients especially micronutrients leading to non-availability to the animal. This results in water pollution and economic loss. In order to improve the water stability of the feeds, binders are used. They also improve the physical form of the feed. Several substances have been tested for their binding ability. Large scale production of experimental diets bound with any binder is limited by its cost, availability and machinery which can be readily utilised in the manufacturing process. In the present study, feeds were formulated for shrimps using various binders at different levels. The visual water stability and the percentage weight loss were assessed. The effect of the prepared feed on the biogrowth parameters were also assessed.

The author thank the Dean, Fisheries College and Research Institute, Thoothukkudi for providing facilities for conducting the above study. This study was conducted using funds provided by Indian Council of Agricultural Research, New Delhi.

Material and methods

A set of experiment was conducted to assess the level of different binders in feed formulation for *Penaeus indicus* Twelve binders, such as agar agar, sodium alginate, gelatin, tapioca flour, carboxy methyl cellulose, carageenan, potato starch, guar gum, polyvinyl alcohol, starch powder, neem gum and acacia gum were used for this study.

Cost of Binders used in the expenditure are given below

Types of binders	Rs./Kg
Tapioca flour	16
Potato starch	90
Starch Powder	264
Guar gum	100
Acacia gum	80
Neem gum	40
Agar agar	300
Sodium alginate	350
Carageenan	430
Gelatin	250
Polyvinyl alcohol	540
Carboxy methyl cellulose	500

In this study experiment was conducted with feeds formulated using different feed ingredients and binders based on the balanced feed formulae. 11 feeds with agar at 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5 and 5% and carboxy methyl cellulose (CMC) at 2.5 and 5%, 12 feeds containing tapioca flour at 5, 10, 15 and 20% feeds with any one of the following binders like sodium alginate, gelatin, carageenan, potato starch, guar gum, poly vinyl alcohol, starch powder and acacia gum and agar agar at 2, 4, 6 and 8% were prepared. Wheat flour was used as filler.

The prepared feeds were tested for visual water stability, which ranked the above shrimp feed pellets according to form and retention of pellet shape. Several pellets were randomly selected from each sample and placed in 250 ml beakers with 100 ml of water. After various time periods, the binders could be easily ranked by arranging the feeds into different distinct groups with the pellet displaying the best visual water stability to the least. The trial was done twice and the mean values were recorded.

The water stability of feed pellets were evaluated by determining the percentage loss in weight in water at specific time intervals. For this experiment cone shaped pouches were made with cloth (1mm mesh). These were thoroughly washed with fresh water and dried at 70°C to constant weight. The feed pellets were cut into pieces of approximately 7mm in length. Fifty pellets were kept in each pouch and the initial weight of the pouches were recorded.

The pouches along with the pellets were then carefully lowered into the trough containing 45 litres of sea water of 25ppt salinity. The temperature and pH of the water were 20°C and 7.85 respectively. Seawater flow rate at one litre/minute and aeration were maintained. After the predetermined periods (1 to 6 hrs), the pouches along with pellets were removed from the trough, washed freed of salt with freshwater, dried at 70°C, cooled and then weighed for dry matter retained. The above experiment was done thrice and the mean values of percentage loss were recorded.

Growth study was conducted to determine the effect of binders on the bioenergetics of shrimp. Approximately 0.5 to 1.0g sized wild prawn of *Penaeus indicus* acclimated to the laboratory condition were used in these experiments. The

duration of experiments were 28 days. Six shrimps were stocked in each of the 45 litre plastic troughs provided with seawater circulation at the rate of one litre per minute and proper aeration. Three tanks were allotted per treatment. The remaining feed and faecal matter were removed each day before feeding, dried and weighed. Troughs were cleaned off feed refusal, faecal matter, molts and mortalities daily. The water quality parameters such as temperature, salinity, dissolved oxygen, pH and ammonia were monitored throughout the trial.

Food consumption, absorption, growth, metabolism, feeding rate, growth rate, absorption rate, metabolism rate, gross conversion efficiency, percentage of growth, feed efficiency ratio, protein efficiency ratio and food conversion ratios were assessed at the end of the experiments using the following formulae.

Food consumption (g) = Food given (g) - Unfed feed collected (g)

Absorption (g) = Consumption (g) - Faeces (g)

Metabolism (g) = Absorption (g) - growth (g)

Growth (g) = Final dry weight (g) - Initial dry weight (g)

$$\text{Metabolic rate} = \frac{\text{Food abosrbed - growth}}{\text{Mid body weight x No. of days}}$$

$$\text{Growth rate} = \frac{\text{Final weight - Initial weight}}{\text{Mid body weight x No. of days}}$$

$$\text{Gross conversion efficiency (\%)} = \frac{\text{Dry growth}}{\text{Food consumed}} \times 100$$

$$\text{Percentage of growth (\%)} = \frac{\text{Live growth}}{\text{Initial weight}}$$

$$\text{Feed efficiency ratio} = \frac{\text{Live growth}}{\text{Dry food consumed}} \times 100$$

$$\text{Protein efficiency ratio(\%)} = \frac{\text{Live growth}}{\text{Total protein consumed}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Dry food consumed}}{\text{Live growth}} \times 100$$

The proximate composition like moisture, ash, fat, carbohydrate and protien content of the prepared feeds were estimated as per AOAC(1995) methods.

The prawns were found to accept all feeds, but the amount taken by the animals varied, depending upon the feed integrity and the type of binders used in the feed. Field study was conducted to assess the effect of formulated feed on growth of *Penaeus* sp. The shrimp seeds collected from local area was used for this study. The seeds were acclimatized in the nursery ponds for 15 days and fed with prepared feeds. Then they were stocked in the grower tanks of 500 l cap. The stocking density was 2.5/m^2. Water depth was 1mt to 1.2 mt. Water quality parameters were maintained. The initial length and weight were recorded. Feed was given initially at the rate of 10% body weight and subsequently were according to the weight of the shrimp. The growth and survival of the shrimp were assessed periodically.

Results and discussion

Table 1 gives the basic component composition of feeds. The proximate compo-

sition of feeds used in the experiments are presented in Table 2. The feeds contain 3.9 to 10.6% moisture, 9.6 to 20.2% ash, 7.1 to 12.6% fat, 39.7 to 42.7% protein and 22.7 to 38.8% carbohydrate respectively. The result of the visual water stability at varied time intervals of the feeds containing different percentage of various binders are presented in Table 3.

The feed containing 5% CMC, 4.5, 5.0 and 8% agar-agar, 6 and 8% sodium aliginate, 6 and 8% guar gum and 4, 5 and 8% neem gum and 4, 6 and 8% polyvinyl alcohol were stable for six hours. Feed containing 4% agar-agar, 4% gelatin and 8% carrageenan were stable for five hours. Feed containing 2.5% CMC, 3 and 3.5% carrageenan, 6 and 8% potato starch, 2% guar gum, 4% neem gum and 2 and 4% starch were stable for an hour only.

The percentage of weight loss of different test feeds at varied time intervals are

Table 1. *Percentage component composition of experimental feeds*

Sl. No.	Ingredients	%	Remarks
1.	Soybean meal	25.0	X1-Filler (adjusted according to the binder percentage)
2.	Fish meal	23.8	
3.	Shrimp meal	8.5	X2-Binders %
4.	Squid meal	8.5	Experiment
5.	Wheat flour	X1	a. Carboxymethyl cellulose : 2.5 & 5
6.	Soy oil	3.0	b. Agar agar 1, 1.5, 2.5, 3, 3.5, 4, 4.5 and 5
7.	Fish oil	3.0	
8.	Lecithin	1.0	Experiment - II
9.	Cholestrol	0.5	a. Tapioca Floor : t, 10, 15 and 20
10.	Vitamin mixture	1.5	b. Sodium alginate : 2, 4, 6 and 8
11.	Mineral mixture	1.0	c. Gelatin : 2, 4, 6 and 8
12.	Vitamin E	0.5	Experiment - III
13.	Vitamin C	0.5	a. Carrageenan : 2, 4, 6 and 8
14.	Papain	0.25	b. Potato starch : 2, 4, 6 and 8
15.	G. Probiotic	0.25	Experiment - IV
	Dicalcium		a. Guar gum : 2, 4, 6 and 8
16	Phosphate	2.0	b. Polyvinyl alcohol : 2, 4, 6 and 8
17.	BHA	0.025	C. Starch powder : 2, 4, 6 and 8
			Experiment - V
			a. Acacia gum : 2, 4, 6 and 8
18.	Binder	X2	b. Agar - agar : 2, 4, 6 and 8
			c. Neem gum : 2, 4, 6 and 8

Table 2. *Experiment - I Proximate composition of feeds*

Sl.	Feed with different binders %		Moisture %	Ash %	Fat %	Protein %	Carbohydrate
1.	CMC	2.5	9.5	18.8	8.5	40.4	23.1
2.	CMC	5.0	10.6	18.0	9.3	40.3	22.7
3.	Agar-agar	1.0	9.4	20.2	8.3	40.8	23.4
4.	Agar-agar	1.5	8.8	18.1	9.4	40.8	24.9
5.	Agar-agar	2.0	8.8	18.3	9.1	40.8	25.1
6.	Agar-agar	2.5	9.4	18.1	8.6	40.8	25.1
7.	Agar-agar	3.0	9.1	18.1	7.9	40.8	25.6
8.	Agar-agar	3.5	9.3	18.3	8.0	40.8	25.6
9.	Agar-agar	4.0	9.0	18.0	8.3	40.8	26.3
10.	Agar-agar	4.5	9.0	18.5	8.2	40.8	25.5
11.	Agar-agar	5.0	9.3	18.3	8.3	40.8	25.4
12.	Tapioca	5.0	5.7	11.3	11.3	11.3	33.6
13.	Tapioca	10.0	6.7	10.7	9.8	40.1	35.7
14.	Tapioca	15.0	6.8	12.0	9.9	41.1	32.2
15.	Tapioca	20.0	7.6	11.6	9.5	40.1	34.3
16.	Sodium alginate	2.0	6.5	9.6	9.5	40.1	34.3
17.	Sodium alginate	4.0	7.2	11.9	11.5	41.3	32.1
18.	Sodium alginate	6.0	8.0	12.2	9.2	40.1	32.1
19.	Sodium alginate	8.0	8.1	13.1	12.6	41.1	31.1
20.	Gelatin	2.0	7.3	11.7	10.0	40.0	33.2
21.	Gelatin	4.0	7.4	11.6	10.2	40.4	38.8
22.	Gelatin	6.0	7.4	10.9	9.8	40.2	33.7
23.	Gelatin	8.0	7.9	10.7	10.3	40.5	33.4
24.	Carrageenan	2.0	5.0	11.3	7.3	40.0	36.4
25.	Carrageenan	4.0	4.9	11.8	7.6	40.8	34.9
26.	Carrageenan	6.0	4.6	10.8	7.9	40.8	37.6
27.	Carrageenan	8.0	4.9	13.5	7.7	40.8	33.1
28.	Potato starch	2.0	4.7	10.9	8.3	40.8	35.3
29.	Potato starch	4.0	4.8	11.0	7.8	40.8	36.6
30.	Potato starch	6.0	4.8	9.7	7.8	40.8	36.9
31.	Potato starch	8.0	3.9	11.0	7.4	40.0	38.0
32.	Guar gum	2	8.42	10.12	7.27	40.26	33.9
33.	Guar gum	4	8.80	10.17	7.30	40.60	33.13
34.	Guar gum	6	8.22	10.06	7.35	40.75	33.62
35.	Guar gum	8	8.69	9.43	7.34	40.75	33.76
36.	Polyvinyl alcohol	2	7.34	9.92	9.49	40.75	34.50
37.	Polyvinyl alcohol	4	7.39	9.72	7.79	40.75	34.35
38.	Polyvinyl alcohol	6	6.98	9.84	7.46	40.75	34.95
39.	Polyvinyl alcohol	8	7.74	9.98	7.28	40.75	34.24
40.	Starch	2	5.87	10.07	7.43	40.75	35.94
41.	Starch	4	5.72	9.78	7.84	40.75	35.94
42.	Starch	6	5.65	9.74	7.13	40.75	36.73
43.	Starch	8	4.42	10.02	7.23	40.25	37.08
44.	Acacia gum	2	4.19	10.09	8.46	39.72	37.54
45.	Acacia gum	4	4.29	10.60	8.32	79.96	36.83
46.	Acacia gum	6	4.68	11.07	8.07	39.87	36.31
47.	Acacia gum	8	4.03	10.74	8.11	39.75	37.37
48.	Agar agar	2	5.21	10.80	8.98	39.68	35.95
49.	Agar agar	4	5.05	10.47	8.46	39.72	36.30
50.	Agar agar	6	5.11	10.45	8.09	40.06	36.29
51.	Agar agar	8	5.25	10.99	8.85	39.68	35.23
52.	Neem gum	2	4.53	9.59	7.48	39.75	37.68
53.	Neem gum	4	4.52	10.30	8.14	40.62	36.42
54.	Neem gum	6	4.59	10.02	8.34	41.71	35.34
55.	Neem gum	8	4.06	10.29	8.98	42.68	33.99

Values are means of duplicates.

Table 3. *Experiment - I Visual water stability of experimental feeds*

Sl.	Feed with different binders %		Duration in hours					
			1	2	3	4	5	6
1.	CMC	2.5	IN	IN	IN	IN	PCR	CR
2.	CMC	5.0	IN	IN	IN	IN	IN	IN
3.	Agar-agar	1.0	CR	-	-	-	-	-
4.	Agar-agar	1.5	IN	IN	PCN	CR	-	-
5.	Agar-agar	2.0	IN	IN	PCR	CR	-	-
6.	Agar-agar	2.5	IN	IN	IN	PCR	CR	-
7.	Agar-agar	3.0	IN	IN	IN	IN	PCR	CR
8.	Agar-agar	3.5	IN	IN	IN	IN	PCR	CR
9.	Agar-agar	4.0	9.0	18.0	8.3	40.8	26.3	
10.	Agar-agar	4.5	IN	IN	IN	IN	IN	IN
11.	Agar-agar	5.0	IN	IN	IN	IN	IN	IN
12.	Tapioca	5.0	CR	-	-	-	-	-
13.	Tapioca	10.0	CR	-	-	-	-	-
14.	Tapioca	15.0	CR	-	-	-	-	-
15.	Tapioca	20.0	IN	CR	-	-	-	-
16.	Sodium alginate	2.0	IN	IN	PCR	PCR	CR	-
17.	Sodium alginate	4.0	IN	IN	IN	PCR	CR	-
18.	Sodium alginate	6.0	IN	IN	IN	IN	IN	IN
19.	Sodium alginate	8.0	IN	IN	IN	IN	IN	IN
20.	Gelatin	2.0	IN	IN	IN	IN	PCR	CR
21.	Gelatin	4.0	IN	IN	IN	IN	IN	PCR
22.	Gelatin	6.0	IN	IN	IN	IN	IN	IN
23.	Gelatin	8.0	IN	IN	IN	IN	IN	IN
24.	Carrageenan	2.0	IN	IN	IN	PCR	-	-
25.	Carrageenan	4.0	IN	IN	IN	PCR	CR	-
26.	Carrageenan	6.0	IN	IN	IN	IN	PCR	CR
27.	Carrageenan	8.0	IN	IN	IN	IN	IN	PCR
28.	Potato starch	2.0	IN	IN	CR	-	-	-
29.	Potato starch	4.0	IN	IN	CR	-	-	-
30.	Potato starch	6.0	IN	IN	IN	CR	-	-
31.	Potato starch	8.0	IN	IN	IN	PCR	CR	-
32.	Guargum	2	IN	IN	IN	PCR	CR	-
33.	Guargum	4	IN	IN	IN	IN	PCR	CR
34.	Guargum	6	IN	IN	IN	IN	IN	IN
35.	Guargum	8	IN	IN	IN	IN	IN	IN
36.	Polyvinyl alcohol	2	IN	IN	IN	PCR	CR	-
37.	Polyvinyl alcohol	4	IN	IN	IN	IN	IN	IN
38.	Polyvinyl alcohol	6	IN	IN	IN	IN	IN	IN
39.	Polyvinyl alcohol	8	IN	IN	IN	IN	IN	IN
40.	Starch	2	IN	PCR	CR	-	-	-
41.	Starch	4	IN	PCR	PCR	CR	-	-
42.	Starch	6	IN	IN	PCR	CR	-	-
43.	Starch	8	IN	IN	PCR	CR	-	-
44.	Acacia gum	2	IN	IN	IN	CR	-	-
45.	Acacia gum	4	IN	IN	IN	CR	-	-
46.	Acacia gum	6	IN	IN	IN	CR	-	-
47.	Acacia gum	8	IN	IN	IN	IN	CR	-
48.	Agar agar	2	IN	IN	PCR	CR	-	-
49.	Agar agar	4	IN	IN	IN	IN	PCR	CR
50.	Agar agar	6	IN	IN	IN	IN	IN	IN
51.	Agar agar	8	IN	IN	IN	IN	IN	IN
52.	Neem gum	2	IN	CR	-	-	-	-
53.	Neem gum	4	IN	IN	CR	-	-	-
54.	Neem gum	6	IN	IN	CR	-	-	-
55.	Neem gum	8	IN	IN	IN	CR	-	-

IN- Intact CR - Crumbled PCR - Partially crumbled

given in Table 4. The weight loss increased with increase in time. After six hours the weight loss was 9.6% for the feed with 5% CMC, 0.7% for the feed with 8% agar-agar, 11% for the feed with 8% sodium alginate, 11.6% for the feed with 20% tapioca flour and 11.8% for the feed with 6% agar-agar. A higher pecentage of weight loss was observed in feed with 8% polyvinyl alcohol (12.96%) and in 6% agar-agar 12.8%. The highest percentage of weight loss was (24.68%) observed in feed with 2% starch powder.

The bioenrgetics of growth, food consumption, absorption, growth rate, feeding rate, absorption rate, metabolism rate, gross conversion efficiency protein efficiency ratio, feed efficiency ratio, percentage of growth and food conversion ratio are presented in Table 5. A maximum growth of 0.031 g was observed in the group fed on feed with 4% carrageenan, as binder while a minimum of 0.0011 g was observed in that fed on feed with 4% neem gum. The highest food consumption of 0.32 g was reported in animal fed with the feed with 2% potato starch, as binder while lowest food consumption of 0.006 g was reported in shrimp fed with feed with 5% agar-agar. The highest absorption of 0.032 g was observed in the group fed with feed containing 2% potato starch and the lowest absorption of 0.018 g was observed in animals fed with feed incorporating 5% agar-agar. A maximum metabolism of 0.29 g was noticed in the group fed with feed with 2% potato starch and a minimum of 0.016 g was noticed in shrimps fed with feed with 5% agar-agar. The growth rate was very high (0.10g) in animals fed with feed incorporating 4% carrageenan and very low (0.0032 g) in that fed with feed containing 8% starch powder. A maximum feeding rate of 0.242 g was reported in groups fed with feed incorporating 2% potato starch and a minimum feeding rate 0.027 g was reported in the groups fed with feed containing 5% agar-agar as binder.

The highest absorption rate of 0.233 g was obtained in the group fed with feed incorporating 8% carrageenan, while the lowest absorption rate of 0.023 g was obtained in the groups fed with feed with 5% agar-agar. A maximum metabolism rate of 0.223 g. was noticed in shrimp fed with feed with 2% potato starch and a minimum of 0.01 g was noticed in animals fed with feed incorporating 5% agar-agar.

The gross conversion efficiency was very high(19.89%) in animals fed with feed containing 1.5% agar-agar and very low (4.30%) in the group fed with feed containing 8% neem gum. The net conversion efficiency was maximum (20.51%) in shrimp fed with feed prepared using 1.5% agar-agar and minimum (4.58%) in fed with 8% neem gum. The protein efficiency ratio was highest (152. 62%) in the group fed with feed with 2% gelatin and lowest (35.99%) in feed groups fed with feed incorporating 8% neem gum. The highest feed efficiency ratio (69.98%) was observed in groups fed with feed containing 1.5% agar-agar and the lowest feed efficiency ratio (11.056%) in that fed with feed 2% carrageenan. A maximum percentage of growth (6.33%) was re-

Table 4. *Experiment - I Weight loss percentage of experimental feeds*

Sl.	Feed with different binders %		Duration in hours					
			1	2	3	4	5	6
1.	CMC	5.0	6.3	6.6	7.6	8.1	9.5	9.6
2.	CMC	2.5	8.3	9.3	9.6	9.7	10.0	10.5
3.	Agar-agar	1.0	14.9	16.0	17.7	18.2	19.1	21.7
4.	Agar-agar	1.5	13.5	14.0	14.3	14.6	16.1	16.4
5.	Agar-agar	2.0	11.8	12.3	13.4	13.6	14.4	14.6
6.	Agar-agar	2.5	11.4	11.9	12.4	12.6	13.0	14.6
7.	Agar-agar	3.0	10.4	11.9	12.2	12.3	12.3	13.4
8.	Agar-agar	3.5	9.4	10.9	11.1	12.2	12.9	13.1
9.	Agar-agar	4.0	8.7	10.3	11.5	11.2	11.4	12.8
10.	Agar-agar	4.5	8.4	10.1	11.6	11.1	11.0	12.3
11.	Agar-agar	5.0	7.1	10.0	10.8	11.4	11.5	11.9
12.	Tapioca	5.0	11.3	11.4	11.8	12.0	12.1	12.2
13.	Tapioca	10.0	10.8	11.0	11.5	12.1	12.2	12.3
14.	Tapioca	15.0	10.9	10.6	11.4	11.5	11.6	11.8
15.	Tapioca	20.0	10.3	10.6	11.4	11.3	11.4	11.6
16.	Sodium alginate	2.0	10.0	10.3	11.2	11.2	11.3	11.4
17.	Sodium alginate	4.0	9.8	10.2	11.0	11.0	11.1	11.1
18.	Sodium alginate	6.0	9.6	10.1	10.6	11.0	11.1	11.1
19.	Sodium alginate	8.0	9.0	9.8	9.3	10.5	10.9	11.0
20.	Gelatin	2.0	10.6	10.6	11.1	11.2	11.2	12.2
21.	Gelatin	4.0	10.5	10.4	11.0	11.1	11.2	12.0
22.	Gelatin	6.0	9.3	9.8	10.1	10.7	11.0	11.1
23.	Gelatin	8.0	8.4	9.0	9.7	10.0	10.1	10.9
24.	Carrageenan	2.0	8.9	11.0	11.4	13.9	16.6	19.5
25.	Carrageenan	4.0	7.5	9.5	11.0	12.5	14.5	19.1
26.	Carrageenan	6.0	7.0	9.0	11.0	11.1	13.0	16.7
27.	Carrageenan	8.0	6.9	8.4	9.4	10.4	11.1	15.0
28.	Potato starch	2.0	9.5	10.5	13.5	18.5	20.0	23.0
29.	Potato starch	4.0	9.1	9.9	11.6	15.5	17.9	20.1
30.	Potato starch	6.0	8.8	8.1	10.0	13.1	15.6	18.4
31.	Potato starch	8.0	7.6	8.0	9.7	12.4	14.9	15.5
32.	Guar gum	2	7.28	9.86	13.42	14.67	16.92	18.32
33.	Guar gum	4	7.16	9.23	12.01	13.64	13.26	16.07
34.	Guar gum	6	6.92	8.42	10.46	12.23	14.01	14.62
35.	Guar gum	8	6.86	8.32	10.16	11.92	13.62	13.96
36.	Polyvinyl alcohol	2	7.26	9.48	12.96	18.48	19.32	20.46
37.	Polyvinyl alcohol	4	7.03	9.23	11.68	12.56	14.62	16.32
38.	Polyvinyl alcohol	6	6.92	8.18	9.96	10.83	12.64	14.12
39.	Polyvinyl alcohol	8	6.82	7.93	9.40	11.62	12.22	12.96
40.	Starch	2	12.68	14.96	18.23	20.58	22.42	24.68
41.	Starch	4	11.96	13.82	16.96	18.91	21.47	20.01
42.	Starch	6	11.23	12.77	16.96	18.91	21.47	20.01
43.	Starch	8	10.84	12.48	14.32	19.96	17.89	19.46
44.	Acacia gum	2	10.6	10.9	12.6	13.3	14.8	15.9
45.	Acacia gum	4	I10.3	10.6	11.9	12.8	13.2	14.6
46.	Acacia gum	6	10.2	10.4	11.6	12.5	12.9	13.8
47.	Acacia gum	8	9.8	10.2	11.3	11.9	12.3	12.9
48.	Agar agar	2	11.9	12.4	13.3	13.6	14.2	14.8
49.	Agar agar	4	8.5	10.1	11.3	11.9	12.2	12.8
50.	Agar agar	6	6.8	9.7	9.9	10.6	11.2	11.8
51.	Agar agar	8	6.7	7.8	8.6	9.8	10.3	10.7
52.	Neem gum	2	10.9	12.7	14.6	14.9	15.5	16.8
53.	Neem gum	4	10.6	11.8	12.9	13.5	14.2	15.6
54.	Neem gum	6	10.4	11.5	12.1	12.9	13.8	14.9
55.	Neem gum	8	10.2	11.3	11.8	12.3	12.8	14.6

Values are means of triplicates

Table 5. *Experiment - I , Bioenergetics of P. indicus fed on feed with different binders*

Sl. No.	Feed with different binders		growth (g)	Food consu-mption(g)	Absorp tion (g)	Metab -olism (g)	Growth (g) rate	Feeding (g)	Absorp tion (g)	Metap olism (g)	Gross conver-sion	Net conver-sion efficiency	Protein efficiency ratio efficiency	Feed effici - ency %	Percent-age of growth %	Food conver-sion ratio %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1.	CMC	2.5	0.0058	0.0356	0.035	0.029	0.055	0.034	0.033	0.027	16.38	18.0	58.62	59.56	2.67	1.74
2.	CMC	5.0	0.0039	0.244	0.022	0.018	0.044	0.027	0.024	0.020	16.14	16.83	53.93	56.07	1.97	1.76
3.	Agar-agar	1.0	0.0537	0.0357	0.034	0.030	0.0036	0.035	0.033	0.029	19.89	10.95	43.72	36.95	1.58	2.72
4.	Agar-agar	1.5	0.0071	0.0359	0.035	0.0180	0.0067	0.038	0.037	0.032	10.48	20.51	63.52	69.98	2.79	1.43
5.	Agar-agar	2.0	0.0057	0.0355	0.033	0.028	0.0051	0.036	0.033	0.028	14.51	15.50	57.69	50.26	2.38	2.00
6.	Agar-agar	2.5	0.0049	0.0348	0.032	0.028	0.050	0.34	0.32	0.26	14.31	15.17	54.61	49.90	2.34	2.09
7.	Agar-agar	3.0	0.0036	0.0307	0.030	0.026	0.0043	0.033	0.031	0.02	11.87	12.35	51.72	41.70	2.03	2.39
8.	Agar-agar	3.5	0.0031	1.0303	0.029	0.025	0.0042	0.032	0.030	0.023	10.28	10.68	49.24	37.43	1.40	2.74
9.	Agar-agar	4.0	0.0026	0.0185	0.025	0.023	0.0240	0.031	0.027	0.021	10.65	10.04	40.03	36.11	1.17	3.16
10.	Agar-agar	4.5	0.0022	0.0104	0.019	0.016	0.0034	0.024	0.026	0.018	9.04	9.82	47.62	33.95	0.98	3.67
11.	Agar-agar	5.0	0.0019	0.0099	0.018	0.016	0.0033	0.027	0.023	0.016	9.67	9.64	46.12	31.62	0.89	3.94
12.	Tapioca flour	2	0.0037	0.034	0.032	0.032	0.0049	0.045	0.042	0.037	8.21	11.59	96.63	31.88	2.43	3.20
13.	Tapioca flour	4	0.0044	0.043	0.41	0.37	0.0050	0.057	0.055	0.049	8.62	10.76	93.57	37.33	3.18	3.14
14.	Tapioca flour	6	0.044	0.051	0.05	0.45	0.0060	0.061	0.057	0.052	10.15	8.93	77.53	40.11	3.32	2.66
15.	Tapioca flour	8	0.0045	0.054	0.054	0.046	0.0062	0.071	0.068	0.062	10.55	8.8	76.51	44.35	3.60	2.49
16.	Sodiumalginate	2	0.0042	0.035	0.034	0.029	0.005	0.045	0.044	0.039	11.87	12.55	109.42	43.90	2.73	2.28
17.	Sodiumalginate	4	0.0036	0.034	0.033	0.029	0.0048	0.044	0.041	0.036	10.47	11.05	93.75	38.72	2.36	2.62
18.	Sodiumalginate	6	0.0031	0.032	0.031	0.028	0.0038	0.043	0.040	0.036	9.62	9.82	68.57	35.55	1.84	2.81
19.	Sodiumalginate	8	0.0029	0.031	0.030	0.027	0.0030	0.040	0.038	0.033	9.15	9.47	82.24	33.89	1.76	2.95
20.	Gelatin	2	0.0053	0.036	0.034	0.029	0.0066	0.048	0.053	0.041	14.47	15.33	152.62	53.50	3.72	1.87
21.	Gelatin	4	0.0048	0.035	0.034	0.029	0.0055	0.043	0.044	0.038	11.80	12.56	107.13	43.89	2.89	2.29
22.	Gelatin	6	0.0039	0.034	0.033	0.029	0.0055	0.043	0.044	0.038	11.80	12.56	107.13	43.89	2.89	2.29
23.	Gelatin	8	0.039	0.033	0.031	0.027	0.0055	0.041	0.043	0.034	11.4	11.82	106.76	42.68	2.65	2.34
24.	Carrageenan	2	0.012	0.135	0.12	0.11	0.010	0.116	0.105	0.095	8.84	9.73	67.92	11.06	6.07	3.12

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25. Carrageenan	4	0.014	0.28	0.19	0.11	0.0106	0.187	0.185	0.124	9.74	9.89	79.82	27.26	6.33	3.09
26. Carrageenan	6	0.011	0.20	0.18	0.17	0.0085	0.167	0.144	0.133	5.58	5.71	49.51	18.13	4.52	5.51
27. Carrageenan	8	0.010	0.19	0.17	0.18	0.0080	0.154	0.235	0.113	5.14	5.7	45.18	17.86	4.42	5.63
28. Potato starch	2	0.013	0.32	0.31	0.29	0.0108	0.242	0.152	0.223	5.16	7.33	58.82	23.69	5.75	4.24
29. Potato starch	4	0.011	0.18	0.16	0.15	0.0088	0.150	0.41	0.138	4.89	6.54	57.82	20.69	4.98	4.84
30. Potato starch	6	0.010	0.15	0.15	0.14	0.0085	0.142	0.140	0.132	4.53	6.44	51.14	18.54	4.61	4.86
31. Potato starch	8	0.0008	0.15	0.15	0.14	0.0079	0.140	0.137	0.128	5.28	5.48	44.22	17.62	3.88	5.39
32. Guar gum	2	0.015	0.053	0.042	0.038	0.0056	0.073	0.060	0.053	7.90	9.88	71.57	29.17	3.05	3.43
33. Guar gum	4	0.028	0.066	0.060	0.053	0.0085	0.083	0.067	0.059	11.62	12.63	95.12	42.83	5.56	2.33
34. Guar gum	6	0.019	0.057	0.047	0.041	0.0058	0.063	0.052	0.046	9.29	11.28	43.44	34.23	3.08	2.92
35. Guar gum	8	0.016	0.052	0.04	0.036	0.0058	0.061	0.047	0.049	8.14	10.3	42.617	30.0	3.03	3.33
36. Polyvinylalcohol	2	0.077	0.053	0.049	0.044	0.0060	0.065	0.060	0.054	9.27	10.06	93.00	37.90	3.57	2.64
37. Polyvinylalcohol	4	0.031	0.079	0.073	0.065	0.0093	0.087	0.081	0.082	10.64	11.47	96.24	39.21	6.15	2.55
38. Polyvinylalcohol	6	0.024	0.071	0.062	0.057	0.0057	0.076	0.067	0.056	7.46	9.47	86.24	35.14	4.29	2.85
39. Polyvinylalcohol	8	0.023	0.062	0.057	0.053	0.052	0.065	0.060	0.055	7.33	8.67	82.57	36.67	3.75	2.65
40. Starch	2	0.022	0.055	0.048	0.043	0.0059	0.064	0.056	0.050	9.15	10.53	99.33	40.47	4.05	2.47
41. Starch	4	0.012	0.037	0.033	0.030	0.055	0.058	0.053	0.047	4.42	10.92	85.27	34.76	2.77	2.88
42. Starch	6	0.088	0.034	0.034	0.025	0.0037	0.057	0.045	0.041	6.48	8.23	58.66	23.90	1.69	4.18
43. Starch	8	0.008	0.031	0.026	0.024	0.0032	0.049	0.040	0.037	6.44	7.78	57.22	23.12	1.41	4.24
44. Acacia gum	2	0.0096	0.148	0.138	0.120	0.138	0.129	0.0090	0.120	6.48	6.97	58.62	23.89	6.19	4.186
45. Acacia gum	4	0.0078	0.141	0.137	0.129	0.136	0.142	0.0081	0.134	5.54	5.70	50.23	20.47	5.12	4.885
46. Acacia gum	6	0.0072	0.138	0.131	0.124	0.133	0.127	0.0070	0.120	5.23	5.48	49.05	19.17	3.98	5.216
47. Acacia gum	8	0.0063	0.128	0.120	0.0144	0.129	0.121	0.0064	0.114	4.94	5.26	44.62	18.18	4.49	5.50
48. Agar agar	2	0.0084	0.143	0.132	0.124	0.141	0.132	0.0083	0.122	5.87	6.35	52.78	21.51	5.26	4.65
49. Agar agar	4	0.0071	0.135	0.119	0.111	0.140	0.123	0.0073	0.115	5.26	6.0	47.30	19.27	4.32	5.189
50. Agar agar	6	0.0064	0.125	0.114	0.107	0.120	0.109	0.0062	0.103	5.24	5.63	46.17	18.82	3.31	8.315
51. Agar agar	8	0.0053	0.104	0.101	0.096	0.108	0.104	0.0055	0.099	5.12	5.25	45.95	18.73	2.81	5.340
52. Neem gum	2	0.0097	0.141	0.130	0.120	0.0138	0.112	0.0083	0.103	6.87	7.46	61.91	25.23	5.34	3.964
53. Neem gum	4	0.0011	0.144	0.139	0.129	0.141	0.117	0.0089	0.108	7.58	7.61	65.22	27.23	6.09	3.673
54. Neem gum	6	0.0063	0.135	0.129	0.123	0.137	0.096	0.0064	0.125	4.57	4.88	40.08	17.14	3.51	5.836
55. Neem gum	8	0.0056	0.130	0.122	0.117	0.136	0.096	0.0059	0.125	4.30	4.58	35.99	15.75	3.12	6.351

Values are means of triplicates

Table 6. *Physico chemical parameters of water in the field trial*

Parameters	Range
Water temperature	26.00±0.70
Salinity ppt	32.00±1.00
pH	7.10 to 7.50
Ammonia - N (ppm)	0.00 to 0.04
Nitrite - N (ppm)	0.02 to 0.40
Phosphate P (ppm)	0.11 to 0.14
Dissolved oxygen (ml/l)	7.10 to 1.50

ported in groups fed on feed with 4% carrageenan, while a minimum percentage of growth (0.59%) was reported in that fed with feed with 5% agar-agar. The highest food conversion ratio (6.35) was observed in shrimp fed with feed incorporating 8% neem gum, while the lowest food conversion ratio (1.43) was observed in the group fed with feed including 1.5% agar-agar as binder.

The water quality maintained in the grower tank during the experiment is given in Table 6. The component composition and the proximate composition of feeds used in the field study is given in Table 7. The growth parameters assessed are given in Table 8.

Feed is the largest item which shares more than 50% of the total cost of production in shrimp farming. If the feed is too hard, it is difficult for the animal to ingest and if it is too soft, the pellet would disintegrate faster resulting in loss of nutrients and water pollution. Ahamed Ali (1988) reported that 2% sodium alginate gave good water stability in shrimp feed than the control feed without binder. New

Table 7. *Component composition and proximate composition of feed used for field trial*

Ingredient	%
Soyabean meal	25.00
Fish meal	35.00
Shrimp meal	8.50
Squid meal	8.50
Wheat flour	10.00
Soya oil	3.00
Fish oil	3.00
Vitamin mix	3.00
BHA	0.03
Binder; Guar gum	4.00
Proximate composition %	
Moisture	8.80
Protein	40.60
Fat	7.70
Ash	11.20

Cost feed Rs. 20/-/kg

(1976) in his review reported the use of 5% guar gum and 2.5 carboxy methyl cellulose in the diets of *Palaemon serratus*. Paulraj (1993) recommended the levels of guar gum and gum acacia at 1-2% and

Table 8. *Results of feeding experiment in grow out pond with formulated feed on Penaeus indicus for 75 days*

Description	
Initial average length(mm)	40±1.5
Initial average weight (g)	1.3±0.5
Final average length (mm)	142±2.5
Final average weight (g)	18.3±10.5
Growth/Shrimp/day	0.156 g/shrimp/day
FCR	2.0
Survival%	65%

alginates at 2-5% in shrimp feeds. In the present study feed with 4% guar gum were water stable, exhibited minimum percentage of weight loss and good growth in *Penaeus idicus* as shown by field study.

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