Effect of Extrusion Processing and Steam Pelleting Diets on Pellet Durability, Water Absorption and Physical Response of *Macrobrachium rosenbergii*

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ABSTRACT : Two hundred and ten post-larvae (PL) of *Macrobrachium rosenbergii* (14.5-14.9 mg) were equally distributed in two experimental groups and fed with either steam cooked or extruded pellet for a period of 60 days. Physical evaluation and growth promoting effect of both the pellets were assessed. Significantly higher ($p<0.05$) water stability, absorption and protein efficiency ratio (PER) were recorded in extruded pellet than the steam cooked pellet. Nutrient loss was minimum in the extruded pellet for which lower feed conversion ratio (FCR) ($p<0.05$) was recorded in this group. However, weight gain, relative growth and specific growth rate (SGR) in both the groups were not significantly different ($p>0.05$). Although insignificant ($p>0.05$) but higher amylase activity was recorded in steam pellet fed group. Survival was not affected by feeding either of the diets. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 9 : 1354-1358)***

Key Words : Extruded Pellet, Growth, *Macrobrachium Rosenbergii*, Physical Quality, Post-Larvae, Steam Pellet

INTRODUCTION

Feed processing technology becomes important to develop a suitable artificial feed for the commercial success of aqua-farming. On the recent past modern extrusion technology has made its appearance in fish/prawn feed processing unit in contrast to the conventional steam pelleting technology. Extruded pellets are processed under higher levels of temperature, pressure at different moisture level than the steam pellets (Robinette, 1977). The manipulation of processing condition in extrusion results gelatinisation of starch. Thus, the extruded pellets are more water stable than the steam pellets (Stickney, 1979). The gelatinisation of starch also increases bioavailability of carbohydrates. Sometimes, the negative effects of extrusion such as poor stability of vitamins especially vitamin C during extrusion (Slinger et al., 1979), maillard reaction and amino acid destruction have to be considered. However, extruded pellets are generally utilized more efficiently, thus reducing the water pollution (Botting, 1991; Kim et al., 1992; Riaz, 1997). Therefore, ideal extruded pellet needs proper standardization of extruder operation for different feed.

Present study was carried out to determine the physical quality of pellets along with physiological response of giant fresh water prawn *Macrobrachium rosenbergii* (De Man) post-larvae in terms of growth, survival, feed efficiency and amylase activity by using both feed processing technologies.

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MATERIALS AND METHODS

Formulation and preparation of experimental diets

Two experimental diets with identical composition (Table 1) were prepared by using either the extrusion cooking or the steam cooking. Prior to extrusion, all the feed ingredients were weighed to the required levels and were thoroughly mixed except vitamin-mineral premix. Then, the feed ingredients mixture was fed to the pilot twin-screw extruder (BTP Ltd., Calcutta, India 700 029) under the following processing conditions: moisture, 20%; barrel temperature, 120°C; feeder screw speed, 90 rpm; barrel screw speed, 430 rpm; cutter speed, 1,100 rpm and die hole diameter, 2.0 mm. The feed emerged from the extruder was added with vitamin-mineral premix and was kept in a hot air oven at 60°C till complete drying.

For steam pellets, all the feed ingredients were mixed as above and required amount of water added to make dough, which was cooked in a pressure cooker for 30 min. The vitamin-mineral premix was added after cooling and passed through hand pelletiser fitted with a die of 2 mm size. Pellets were collected and were kept in a hot air oven at 60°C till to get constant weight.

Physical evaluation of experimental diets

Water stability : Feed samples of 5 g each in duplicates were placed in wire net containers immersed in 2 L beaker containing freshwater. The beaker was kept on a magnetic stirrer to simulate mild water flowing condition for periods of 0.5, 1, 2, 4, 6, 8, 10 and 12 h. After each time interval the feed samples from container were collected by draining water and dried at 60°C till complete drying. Water stability was calculated by

Table 1. Physical and proximate composition of the experimental diets (% DM basis)

Ingredients	Extruded/steam pellets
Anchovy meal	10.0
Prawn head meal	25.0
Acetes meal	10.0
Groundnut oil cake	25.0
Wheat flour	10.0
Tapoica powder	10.0
Cod liver oil	2.5
Sunflower oil	2.5
Sodium alginate[1]	2.0
Sodium hexa metaphosphate[1]	1.0
Vitamin mineral mix[*2]	2.0
	100
Proximate composition of feed	
Crude protein	35.0
Ether extract	8.0
Crude fibre	7.0
Nitrogen free extract[3]	33.0
Total ash	17.0

[1] All the chemicals used were from Merck India limited

[*2] Vitamin and mineral mix (Suplevite-M, Sarabhai Chemicals, Baroda, India); a 2.5 kg pack contained vitamin A, 5,000,000 I.U.; Vit D3, 1,000,000 I.U.; Vit B2, 2 g; Vit E, 750 I.U.; Vit K, 1 g; Cal. pantothenate, 2.5 g; Nicotinamide, 10 g; Vitamin B12, 6 g; Choline chloride, 150 g; Calcium, 750 g; Manganese, 27.5 g; Iodine, 1 g; Iron, 7.5 g; Zinc, 15 g; Copper, 2 g; Cobalt, 0.45 g; Vit C was supplemented separately in the form of Celein tablets, Glaxo Company, India @ 300 mg kg^{-1} diet.

[3] Crude protein, fat, crude fibre and ash were analysed on a dry matter basis; NFE (%) was calculated as (100-%CP-%EE-%CF-%Ash).

$$\text{Water stability (\%)} = \frac{\text{Dry weight of pellets after immersion}}{\text{Dry weight of pellets before immersion}} \times 100$$

Water absorption rate : Feed samples of 5 g each in duplicates were placed in wire net container and immersed in 2 L beaker containing freshwater at room temperature for periods of 1, 3, 5 and 10 min. After each specified time period the feed samples were removed and allowed to drain for one minute followed by weighing. The water absorption rate was calculated by

$$\text{Water absorption (\%)} = \frac{\text{Wet weight of pellets after immersion}}{\text{Dry weight of pellets before immersion}} \times 100$$

Expansion ratio and bulk density : Expansion ratio (%) was calculated as described by Oliveira et al. (1992). The average pellet diameter was determined by a vernier caliper. The expansion ratio was calculated as the increase in the pellet cross-sectional area compared to the die cross-sectional area as follows:

$$\text{Expansion ratio (\%)} = \frac{(D_{pellet})^2}{(D_{die})^2} - 1 \times 100$$

where, D_{pellet}=pellet diameter, D_{die}=die diameter

Bulk density of the pellets were calculated as follows:

$$\text{Bulk density (g/cm}^3\text{)} = \frac{M}{A \times L}$$

where, M=Mass (g) of the pellet.

L=Length (cm) of the pellet.

A=Cross-sectional area (cm^2) of the pellet.

Collection and maintenance of post-larvae

Healthy post-larvae of *Macrobrachium rosenbergii* (De Man) collected from a hatchery were acclimated for 15 days in a 300 L water tank. Two hundred and ten post-larvae of uniform size (14.5-14.9 mg) were equally distributed in 14 plastic tubs (50 L) and equally allocated to two experimental groups with seven replication each. All the plastic tubs were provided with shades to prevent cannibalism and were aerated round the clock. Post-larvae of either group was fed twice daily and feeding rate was adjusted to allow minimum left over on the container. About 2/3rd volume of water from each tub was exchanged once a day before feeding along with the siphoning out the faecal matter and residual feed. The feed intake was recorded by subtracting the amount of dry residual feed recovered from the amount of dry feed given.

Growth performance

The body weights were recorded at 15 d interval to assess the growth parameters such as absolute weight gain, SGR, FCR and PER. Survival (%) of post-larvae during the experiment was also recorded.

Amylase activity

One prawn from each experimental unit of both groups viz. extruded pellet fed group and steam pellet fed group was collected at the beginning, 30 days and 60 days of feeding. The whole body of the prawn was taken for determination of amylase activity as described by Somogyi (1945).

Biochemical analysis of experimental diet and prawn tissue

The moisture, ash and nitrogen free extract contents of the diets were determined using the method of AOAC (1980). Crude protein content of the diets was determined by Micro-Kjeldahl method whereas, crude fiber and ether extract level in the diets were determined by using Fibretec system: Model M, 1017 hot extraction unit, Tecator and Soxtech system (Model ST2, 1045 extraction unit, Tecator), respectively.

The moisture and ash content of the prawn tissue were determined by the same method described previously. Total

carbohydrate and protein levels were determined following the procedure of Plummer (1988) and Lowry et al. (1951), respectively. Lipid content of the tissue was determined by methods described by Bligh and Dyer (1959).

Physico-chemical parameters of water

Water quality parameters such as water temperature, pH, dissolved oxygen, free carbon dioxide, ammonia nitrogen and nitrate nitrogen were recorded at 5 days interval by the procedure of APHA (1992).

Statistical analysis

The data were statistically processed either by one way analysis of variance or independent T-test and, where applicable, difference of the means were determined at 5% level using DMRT as described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSIONS

Pellet durability and water absorption rate

The pellet quality was evaluated through water stability (Table 2) and water absorption test (Table 3). The extruded pellet was almost water stable up to 4 h, after that pellet disintegrated significantly ($p<0.05$). However, steam cooked pellet disintegrated significantly ($p<0.05$) within 1 h of immersion in water. The disintegration rate increased proportionately with the exposure time to water. About 10% of the DM was lost within 30 min in steam cooked pellet whereas, it took almost 4 h in extruded pellet for the same amount of loss.

Similarly water absorption capacity of extruded pellet was significantly higher ($p<0.05$) than the steam cooked pellet. About 50% of the water absorbed within 10 min of immersion in steam cooked pellet whereas, it took 5 min in extruded pellet. High water absorption of the extruded pellet was due to expansion and hence, less bulk density of extruded pellet.

Extruded pellet was observed to be more water stable than the steam pellet, even if synthetic binder (sodium alginate) and sequestrant (sodium hexametaphosphate) was used in both diets. Synthetic binder with sequestrant is necessary for a formulation containing shrimp meal, fish meal or fish soluble because the calcium or other cations present in fish by-products prematurely react with alginate when water is added, thus making the diets water unstable (Meyers and Butler, 1972). Superior water stability of the extruded pellets may be due to the gelatinisation of dietary starch during extrusion under high temperature, high pressure and high shear. Greater water absorption by extruded pellets might be due to lower density (1.08 g/cm^3) than that of steam pellet (1.17 g/cm^3). The extent of expansion ratio (14.66%) of extruded pellets was almost comparable (about 11%) of extruded prawn feed reported by Banerjee and Chakrabarty (1997). This ratio is quite conductive for making the sinking type pellet as required by prawns. When the pellets are exited from the extruder die, the sudden pressure drop causes the evaporation of trapped water and formation of air pockets. This little entrapment of air in the extruded pellet might have led to the reduced bulk density (1.08 g/cm^3) than that of steam pellet (1.17 g/cm^3). This result is in agreement with Hilton et al. (1981) and Mgbenka and Lovell (1984).

Table 2. Water stability (%) of extruded or steam pellet at different time interval

Time interval (h)	Water stability (%)		±SEM
	Extruded pellet	Steam pellet	
0.5	98.68^{aA}	92.13^{bA}	0.93
1.0	96.83^{aA}	81.39^{bB}	1.07
2.0	95.37^{aA}	70.75^{bC}	0.97
4.0	88.18^{aAD}	66.12^{bcD}	0.92
6.0	83.49^{aBD}	59.12^{bDE}	2.15
8.0	80.65^{aBD}	54.36^{bEF}	1.06
10.0	76.31^{aC}	50.44^{bEF}	3.30
12.0	71.41^{aC}	47.51^{bF}	2.77
±SEM	4.74	4.74	

Figures containing same superscript in a column (A, B, C, D) and same superscript in a row (a,b) do not differ significantly ($p>0.05$).

Table 3. Water absorption (%) of experimental diets at different time interval

Time interval (h)	Water stability (%)		±SEM
	Extruded pellet	Steam pellet	
1.0	30.79^{aA}	25.49^{bA}	0.39
3.0	43.13^{aB}	35.19^{bB}	1.08
5.0	53.51^{aC}	42.30^{bC}	0.90
10.0	64.87^{aD}	55.11^{bD}	1.03
±SEM	1.35	1.18	

Figures containing same superscript in a column (A, B, C, D) and same superscript in a row (a,b) do not differ significantly ($p>0.05$).

Growth parameters and FCR

The growth parameters are given in Table 4. During the experimental period a trend of lower feed intake was observed for extruded pellet fed group than that for steam pellet fed group. The increased water stability property might have retarded the digestive process in the gut of *M. rosenbergii* post-larvae and thereby might have increased the gastric emptying time. This delayed gastric emptying time was reported by Hilton et al. (1981) after feeding rainbow trout with extruded pellet.

Better FCR was recorded in extruded pellet fed group than steam pellet fed group. This can be co-related with the less feed intake of extruded feed. Poorer FCR of steam pellet fed group might be due to over estimation of feed intake as it was prone to leaching. The increased water stability of extruded pellet had increased the feed efficiency.

Table 4. Growth and survival of post-larvae fed experimental diets

Parameters	Extruded pellet	Steam pellet	±SEM
avg initial BW (mg)	14.5	14.9	1.92
avg final BW (mg)	272.0	291.3	14.22
BW gain (mg)	257.5	276.4	
Relative growth	17.76	18.55	
Feed given (mg/PL/60 days)	499.32[a]	599.02[b]	32.14
FCR	1.94[a]	2.16[b]	0.08
SGR	4.88	4.95	0.95
PER	1.48[a]	1.31[b]	0.06
Survival	95.19	95.19	2.40

Figures containing same superscript in a row do not differ significantly ($p>0.05$).
WG (%)=(Final wt.-initial wt.)×100.
SGR=[(ln Final wt.-ln initial wt.)/60 days]×100.
FCR=[Wt. gain (g)/feed given (g)].
PER=Wt. gain/protein intake.
Survival=Initial stock/Final stock×100.

with little loss of feed. Obaldo et al. (2000) reported that moisture level is the contributing factor for water stability of the extruded feed. He also found that about 20-30% level moisture in the shrimp diet increased the water stability, growth and feed efficiency. Similar type of observation was also made by many workers (Cappell, 1984; Takeshi et al., 1991 and Pongmaneerat and Watanabe, 1993). PER of extruded pellet was about 10.81% higher than that of steam pellet. Whereas, Cappell (1984) reported about 25% higher PER value in trout for extruded pellets than that of steam pellets. Even though less protein intake was recorded in the extruded pellet fed group, better protein efficiency might have been contributed by the optimum utilization of protein.

Although insignificant ($p>0.05$), a higher amylase activity (Figure 1) was noted in steam cooked pellet fed group during the experimental period. Higher amylase activity indicates better availability of carbohydrate from steam pellets than the extruded pellets. Obaldo et al. (2000) suggested that shear is the contributing factor for the starch gelatinization and thus carbohydrate utilization. This indicates shear (430 rpm) was not optimum and needs further standardization for better carbohydrate utilization in extruded feed by *M. rosenbergii* post-larvae.

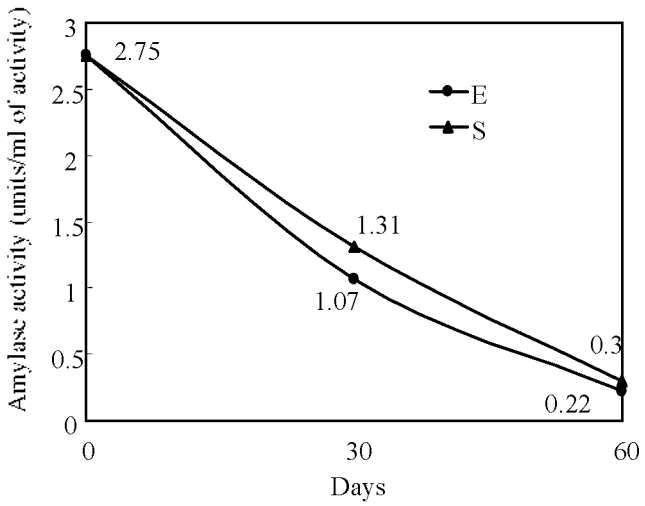

Figure 1. Amylase activity (units/ml of extract) of the two experimental groups at different time interval.

Biochemical composition and survival of post-larvae

The proximate composition of the body tissue is given in Table 5. No significant ($p>0.05$) difference were found in final tissue proximate composition of the whole post-larvae at the end of the feeding. Hilton et al. (1981) reported similar results on trout when fed with either steam cooked or extruded pellet. Similarly no significant difference were detected in proximate analysis of the extruded and steam pellets. Water temperature prevailed during the experimental period was 21-25°C; pH varied from 7.4 to 7.9, dissolved oxygen ranged from 6.2 to 7.0, total alkalinity 175-200 ppm; total hard ness, 85-180 ppm and ammonia nitrogen, 0.08 to 0.10 ppm which was within the normal range as reported by Naik et al. (2001). Survival rate in both groups were same indicating moisture, shear and temperature did not show any significant effect on survival of post-larvae.

CONCLUSION

In conclusion extrusion process produced the pellets of better water stability than steam cooked pellets for M. rosenbergii post-larvae. Extruded pellets induced lower feed intake, better FCR and protein utilization. However, growth promoting effects of both pellets in M. rosenbergii were not significantly different from each other. Tissue composition or survival rate was not affected by the type of the processing technology. Extrusion processing for feed of *M. rosenbergii* post-larvae needs standardization for optimum shear for better carbohydrate utilization.

Table 5. Body tissue composition of experimental groups (% DM)

Parameters	Initial	Final		±SEM
		Extruded pellet	Steam pellet	
Moisture	78.19	73.65	74.15	2.92
Dry matter	21.81	26.35	25.85	0.63
Organic matter	80.00	82.76	83.87	3.67
Crude protein	62.61	69.28	69.54	0.41
Total lipid	3.03	4.04	3.60	0.38
Total ash	20.00	17.24	16.13	0.91
Total carbohydrate	14.36	9.44	10.73	0.73

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