Replacement of fish meal with MBM and PBM on growth performance of juvenile Black Tiger Shrimp (P. monodon) (2003, Vietnam –2)

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ABSTRACT

The objective of this trial was to measure the growth response of juvenile black tiger shrimp when fed practical diet containing various levels of MBM and PBM in substitution of Fish meal (0, 20, 40, 80%). The control diet contained 35% fish meal, which was replaced on an equal protein basis by MBM and PBM for the test diets. Shrimp were raised in indoor aquarium for 60 days. Results showed that 1) PBM can replace FM up to 80% without harming the performance but for MBM, the level was 20%, 2) growth rate for all diets was below normal average, and 3) substitution could result tin substantial savings in feed cost. The trial should be repeated in the future.

% FM	MBM				PBM		
Replacement rate	0	20	40	60	20	40	60
Formulation							
FM[1]	35	28	21	7	28	21	7
MBM[2]	0	8.7	17.4	34.9	0	0	0
PFGPBM[3]	0	0	0	0	6.9	13.8	27.7
SBM [4]	33.8	34.4	35	36.1	33.8	33.7	33.7
Performance (70D)							
Initial Wt (g)	.06	.06	.06	.06	.06	.06	.06
Final Wt (g)	.99[c]	.76 [b]	.74 [b]	.44 [a]	.97 [c]	.97 [c]	.9 [c]
SGR (%)	3.92 [a]	4.09 [a]	3.98 [a]	5.76 [b]	4.09 [a]	3.93 [a]	4.06[a]
Survival (%)	80	71	65	69	79	66	73

[1] Fish Meal
[2] Meat and Bone Meal
[3] Pet food grade poultry byproduct meal
[4] Soybean meal

INTRODUCTION

Aquaculture is the fastest expanding food producing sector in the world, growing at a rate of almost 12 % p.a since 1984, with production almost trebling from 13 to 36 million tones in the last 10 years (Tacon, 1999). Directly correlated with this expanding industry is an increase in feed production and, subsequently, an increase demand for fish meal. Fish meal has high nutritive value, palatability and is one of the most important ingredients in formulated aquafeed, particularly in shrimp feeds where it is typically included at between 200–300 $g.kg^{-1}$. Its inclusion is primarily for its high quality protein but has the additional benefit of its oil content and associated highly unsaturated fatty acids. However, world fish meal production has remained relatively static at 6.2 million tones in 1997 and it is unlikely to increase, only 4.75 million tones were produced in 1998 (Tacon, 1999). It is evident from these statistics that continued expansion of aquaculture will not be possible if fish meal is relied upon as the main source of protein in aquafeeds. Moreover, demand for fishery product from other high profit sectors, such as pet food industry, will force fish meal prices up until its usage in aquafeed will become uneconomical. If aquaculture is to become a net and increasing contributor to human food supplies, it is critical that aquafeeds become less reliant on fishery products, which will mean finding suitable and cost-effective terrestrial alternatives.

Meat-and-bone Meal (MBM) and poultry-and-bone meal (PBM) are possible substitutes for the fish meal component of aquaculture feeds. The annual production of MBM and PBM is 177,270mt and 2,819,322mt, respectively (Hardy, 1999). However, the use of MBM and PBM has tendency to produce variable growth results due to inconsistency in product quality (e.g., quality of raw ingredients, type of processing). For example, there may be reduction in digestibility of the animal by product meal due to high levels of lipid, ash, and indigestible fibre (Robinson and Li, 1996).

Total replacement of fish meal with animal protein (shrimp meal (SM), blood meal (BM), meat and bone meal (MBM), BM+MBM mix and poultry by-product meal (PBM)) has been tested with Nile tilapia *Oreochromis niloticus* (El-Sayed, 1998). Partial replacement of fish meal with MBM has been tested with Japanese fouder *Paralichthy solivaceus* (Kikuchi *et al*. 1997), yellowtail *Seriola quinqueradiata* (Shimeno *et al*. 1993). The use of PBM as partial replacement for fishmeal has been evaluated for Australia snapper *Pagrus auratus* (Quartaro et al. 1998). Chinook salmon *Oncorhynchus tshawytscha* (Fowler, 1991).To date, however, there is no information concerning the replacement of fishmeal by PMB and MBM as the primary protein sources in the diet for Black tiger shrimp (*Penaeus monodon*). Thus objective of the study is to measure the effect of MBM and PBM substitution for fish meal on growth performance of black tiger shrimp from post-larvae to juvenile stage.

RESEARCH METHODOLOGY

Test animals: Fifteen-day old post-larvae (PL_{15}) black tiger shrimp (*Penaeus monodon)* were obtained from hatchery in Can Tho city. They were nursed in a composite tank of 4 m^3 for 15 days or PL_{30} to reach an average size of 0.10 g/pcs. During the nursing period, shrimp were fed a CP commercial pellet of 40 % protein content.

Experimental system: the study was conducted in a set of twenty-eight 700-litre composite tanks. Each tank contained 500-litre of rearing water having a salinity of 20 ppt. Brackish water was prepared by mixing super-saline water of 80 ppt and freshwater. All tanks were sited under a transparent roofed-house. The study was composed of seven treatments including one control and six different test diets. Rearing tanks were arranged following a completely randomized design in four replicates for each treatment. Seventy-five animals were released into each tank randomly.

Test diets and feeding: the nutritive value of the ingredients (fish meal, MBM and PBM) were collected and analyzed to determine their proximate composition before diets were formulated (Table 1). Seven iso-nitrogenous diets were prepared to contain 40 % protein level using computer program. The control treatment contained 35 % fish meal. Six test diets were substituted fish meal by 80, 40 and 20 % MBM and PBM (Table 2). Shrimp were fed by hand to satiation four times daily at 7:00, 11:00, 16:00 and 20:00 hours for 60-days of experiment. The amount of feed consumed per tank was adjusted daily basis.

Tank management: experimental tanks were closely observed for water quality and shrimp health. Tank bottom was siphoned every 2 days to remove un-eaten feed and feces. Water was exchanged every 15 days at a rate of 50 % of total volume. Water quality characteristics were also measured daily for temperature (at 7:00 and 15:00 hr.) and weekly for pH, salinity, alkalinity, N-NH_3, N-NO_2, COD, and DO at 7:00 hr.

Data collection and analysis: initial weight of shrimp was measured by weighing 30 animals. Weight and length gain of shrimp were measured randomly 15 animals every 15 days. Collected data were used for computing values such as survival rate (SR), specific growth rate (SGR), weight gain (%), daily weight gain (DWG), feed conversion ratio (FCR).

SR (%) = 100 * (number stocked / number harvested)
SGR (%/day) = 100 * (log final weight – log initial weight)/days of experiment
DWG (g/day)= (final weight – initial weight)/days of experiment
FCR = feed consumed (dry weight)/live weight gain (wet weight)

All data collected were subjected to one-way analysis of variance using STATISTICA computer program. Differences in treatment means were compared by Duncan's new multiple range test at $p<0.05$.

Table 1: Proximate composition (%) of meat and bone meal (MBM) and poultry and bone meal (PBM) and fish meal (FM). All determinations are reported on a dry weight basis.

Composition	Fish meal (FM)	Poultry Bone Meal (PBM)	Meat Bone Meal (MBM)
Crude protein	62.2	63.0	50.0
Crude lipid	7.00	16.1	16.1
Carbohydrate	2.45	3.09	8.59
Ash	25.7	13.8	23.0
Fibre	2.62	4.00	2.30

Table 2: Composition and proximate analysis of test diets

Composition of test diets (% dry matter basis)							
Feed ingredient	Control diet	Substitution of FM by PBM			Substitution of FM by MBM		
		80	40	20	80	40	20
Fish meal	35.0	7.0	21.0	28.0	7.0	21.0	28.0
Soybean meal	33.8	33.7	33.7	33.8	36.1	35.0	34.4
PBM	0	27.7	13.8	6.9	0	0	0
MBM	0	0	0	0	34.9	17.4	8.7
Wheat flour	20.2	20.6	20.5	20.3	11.1	15.6	17.9
Squid oil	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lecithin	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Cholesterol	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cellulose	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	100	100	100	100	100	100	100

Proximate composition of test diets (% dry matter basis)							
Feed ingredient	Control diet	FM replaced by PBM			FM replaced by MBM		
		80	40	20	80	40	20
Protein	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Lipid	9.2	11.7	10.4	9.8	12.8	11.0	10.1
NFE	29.9	30.4	30.2	30.0	25.2	27.5	28.7
Ash	14.6	11.2	12.9	13.7	15.5	15.1	14.8
Fibre	6.4	6.7	6.5	6.4	6.5	6.4	6.4
Total	100	100	100	100	100	100	100

RESULTS AND DISCUSSION

Water quality

Averages and standard deviations for water quality parameters such as temperature, pH, dissolved oxygen, alkalinity, COD, $N\text{-}NO_2$ and $N\text{-}NH_4$ are summarized in Table 4. Generally, the water parameters of the experiment were in a suitable range for the normal growth of shrimp.

Table 4: Average values of water quality parameters during the experiment

Parameters	Time of sampling	Control diet	Substitution of FM by PBM			Substitution of FM by MBM		
			80 %	40 %	20 %	80 %	40 %	20 %
Temperature	Morning	29.1 (0.93)	29.1 (0.92)	29.1 (0.94)	29.1 (0.94)	29.1 (0.92)	29.1 (0.94)	29.1 (0.92)
	Afternoon	29.7 (0.91)	29.8 (0.87)	29.7 (0.94)	29.7 (0.94)	29.8 (0.87)	29.7 (0.94)	29.8 (0.87)
PH	Morning	7.48 (0.21)	7.54 (0.22)	7.47 (0.19)	7.55 (0.22)	7.56 (0.16)	7.53 (0.17)	7.59 (0.17)
	Afternoon	7.54 (0.18)	7.58 (0.22)	7.53 (0.16)	7.60 (0.19)	7.62 (0.10)	7.58 (0.14)	7.63 (0.16)
Dissolved oxygen		7.22 (0.30)	7.22 (0.19)	7.19 (0.36)	7.21 (0.30)	7.20 (0.30)	7.20 (0.34)	7.22 (0.27)
Alkalinity		85.7 (6.07)	89.3 (8.79)	89.7 (10.5)	90.6 (10.0)	89.4 (12.3)	90.0 (11.4)	89.7 (9.72)
COD		11.6 (2.84)	11.3 (2.95)	12.0 (3.28)	11.9 (3.48)	10.6 (2.80)	11.3 (3.18)	10.9 (3.35)
N-NO2		0.60 (0.28)	0.58 (0.29)	0.60 (0.27)	0.60 (0.28)	0.60 (0.29)	0.64 (0.25)	0.63 (0.26)
N-NH4		0.39 (0.29)	0.36 (0.33)	0.55 (0.90)	0.32 (0.29)	0.29 (0.27)	0.27 (0.22)	0.30 (0.27)

Values in parenthesis are standard deviations
FM: fish meal
MBM: Meat bone meal
PBM: Poultry meat meal

Effects of various substitution levels of fish meal by MBM and PBM on survival rate and growth of shrimp after 60 days of experiment

The survival rates of shrimp are presented in Table 5 and Annex 1. The survival rate ranged from 64.7 to 80 %. Survival rates did not differ significantly ($p>0.05$) among treatments.

Growth in terms of specific growth rate (SGR) and daily weight gain (DWG) of shrimp fed different levels of substitution of FM by PBM and MBM are shown in Table 6. Growth of shrimp fed 80, 40 and 20 % PBM diets were significantly higher than that of shrimp fed 80, 40 and 20 % MBM but not significantly different from shrimp fed the basal diet. There was noticeable decrease in growth associated with increasing more than 20 % of MBM in diets. Growths of shrimp fed 80 % of substitution of FM by MBM were significantly lower than those fed other levels of substitution of FM by PBM and MBM. There was also no significant difference of growth between shrimp receiving 40 % and 20 % MBM diets. In addition, shrimp fed different levels of substitution of FM protein by MBM had higher size variation (Annexes 6-12) than those fed other diets.

It has been noted that substitution of FM by MBM negatively affected performance of red drum due to poor digestibility compared with fish meal, poor palatability (Kureshy, 2000). Several marine species have exhibited a low tolerance to inclusion of MBM. Kikuchi *et al*. (1997) indicated that in growth trials with Japanese fouder, substitution of FM at levels greater than 20 % resulted in reduced percent weight gain. Shimeno *et al*. (1993) reported that substitution of FM with MBM at levels grater than 19.2 % in practical diet for yellow tail resulted in reduced growth parameters. Moreover, Japanese fouder and yellowtail exhibited high FCR with increasing MBM in the diet. Based on the results of this experiment and those with other species, the inclusion of MBM at level above 20 % of the diet is not recommended.

Quartaro *et al.* (1998) reported that a combination of PBM and soybean meal could be used to replace up to 53.1 % of FM in Australian snapper diet containing 64 % FM without depressing growth. Juvenile chinook salmon show no reductions in growth or feed conversion with replacement of up to 50 % fish meal with PBM (Fowler, 1991). The present study shows that up to 80 % inclusion of PBM in shrimp feed doest not adversely affect the growth of shrimp. Thus, the favorable results for substitution of FM with the PBM in this study may be attributed to the practical diets for shrimp.

Other possible explanation for the low performance at increasing levels of fish meal substitution by MBM may be the resulting effect on diet digestibility. The apparent digestibility of MBM has not been determined for shrimp. High ash content in MBM may lower the digestibility of the diets that may have further caused the lowering in growth rates. In this study, the increase in ash content from 14.8 to 15.5 % with increasing levels of MBM was reflected in the proximate analysis of the diets.

Growth in term of size of shrimp fed different levels of substitution of FM by PBM and MBM are shown in Table 7. Shrimp fed different levels of substitution of FM by MBM had lower size, ranging from 41,8 to 49.8 mm than those fed other levels of substitution of FM by PBM and the basal diet.

Table 5: Survival rates of shrimp after 60 days fed different levels of substitution fish meal protein by MBM and PBM

Treatment	Survival rate (%)
Control (basal diet)	80.0±5.00
80 % PBM	73.3±14.0
40 % PBM	65.7±15.6
20 % PBM	78.7±19.0
80 % MBM	68.7±11.9
40 % MBM	64.7±10.0
20 % MBM	71.3±15.6

Table 6: Growth performance of shrimp after 60 days fed different levels of substitution fish meal protein by PBM and MBM.

Levels of substitution	Initial weight (g)	Final weight (g)	SGR (%/day)	DWG (g/day)
Control (basal diet)	0.06±0.1	0.99±0.40[c]	4.66±0.13[c]	0.015±0.001[c]
80 % PBM	0.06±0.1	0.90 ±0.38[c]	4.51±0.17[c]	0.014±0.002[c]
40 % PBM	0.06±0.1	0.97±0.39[c]	4.63±0.18[c]	0.015±0.002[c]
20 % PBM	0.06±0.1	0.97±0.35[c]	4.62±0.32[c]	0.015±0.003[c]
80 % MBM	0.06±0.1	0.44±0.19[a]	3.30±0.28[a]	0.006±0.001[a]
40 % MBM	0.06±0.1	0.74±0.32[b]	4.16±0.51[b]	0.011±0.002[b]
20 % MBM	0.06±0.1	0.76±0.32[b]	4.21±0.18[b]	0.012±0.001[b]

Table 7: Average length(mm) of shrimp after 60 days fed different levels of substitution fish meal protein by PBM and MBM.

Levels of substitution	Initial length (mm)	Final length (mm)
Control (basal diet)	23.3±1.26	53.9±7.14[cd]
80 % PBM	23.3±1.26	53.2±6.90[bd]
40 % PBM	23.3±1.26	54.7±8.25[d]
20 % PBM	23.3±1.26	54.1±7.1[cd]
80 % MBM	23.3±1.26	41.8±6.03[a]
40 % MBM	23.3±1.26	49.8±7.1[bc]
20 % MBM	23.3±1.26	49.1±7.69[b]

Effects of various replacement levels of fish meal by MBM and PBM on FCR of shrimp after 60 days of experiment

The shrimp fed diets with 20-80 % PBM diets and 20-40 % MBM diets showed significantly lower FCR compared to those fed with 80 % MBM diet; and were not significantly different from the basal diet.

Table 8: FCR of shrimp after 60 days fed different levels of substitution fish meal protein by MBM and PBM

Levels of substitution	FCR
Control (basal diet)	3.92 ± 0.51[a]
80 % PBM	4.06 ± 0.25[a]
40 % PBM	3.83 ± 0.63[a]
20 % PBM	4.09 ± 1.01[a]
80 % MBM	5.76 ± 0.75[b]
40 % MBM	3.98 ± 0.64[a]
20 % MBM	4.07 ± 0.48[a]

CONCLUSIONS

- Water quality during the experimental period was suitable for the normal growth of black tiger shrimp *(Penaeus monodon).*
- There was no significant difference in survival rate among treatments.
- The average length and growth of shrimp fed 80 % MBM diet was the lowest. MBM used in this study was not acceptable as a replacement of 20 % FM protein.
- The study demonstrates that the substitution of up to 80 % FM protein by PMB protein in practical diet for *Penaeus mondon* is applicable. Thus, the use of PBM appears to be viable option in practical diets for *Penaeus monodon.*

References

El-Sayed, A. F.M., 1998. Total replacement of fish meal with animal protein sources in Nile Tilapia, Oreochromis niloticus (L.), feeds. Aquaculture research, 29: 275-286.

Fowler, L.G., 1991. Poutry by product meal as a dietary protein source in fall chinook salmon diets. Aquauclture 99: 309-321.

Hardy, R.W., 1999. Aquaculture's rapid growth requirements for alternate protein sourcec. Feed Management 50:25-28.

Kikuchi, K., Sato, T., Furuta, T., Sakaguchi, I., and Deguchi, Y., 1997. Use of meal and bone meal as a protein source in the diet of juvenile Japanese flounder. Fisheries Science 63: 29-32.

Kureshy, N., Davis, D.A., Arnold, C.R.,2000. Partial replacement of fishmeal with meat-and- bone meal, flash-dried poultry by-product meal, and enzyme-digested poultry by- product meal in practical diets for juvenile Red drum. North American Journal of Aquaculture 62: 266-272.

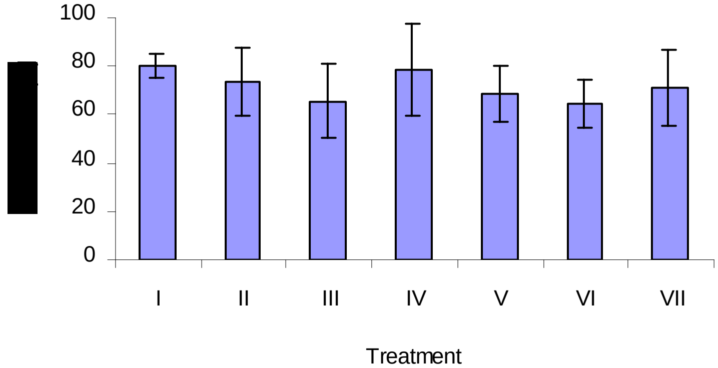
Quartaro, N., Allan, G.L, Bell, J.D., 1998. Replacement of fishmeal in diets for Australian snapper, *Pagrus auratus.* Aquaculture 166: 279-295.

Robinson, E.H., and Li, M.H., 1996. A pratical guide to nutrition, feeds, and feeding of catfish. Mississippi Agricultural and Forestry Experiment Station, Bulletin 1041, Mississppi Sate.

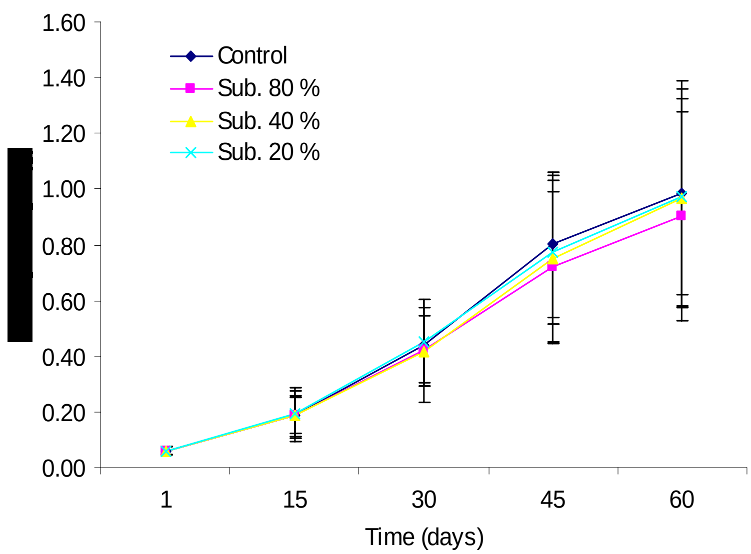
Shimeno,S., Masumoto, T., Hujita, T., Mima, T., Ueno, S., 1993. Alternative protein sources for fish meal in diets of young yellowtail. Nippon Suisan Gakkaishi 59: 137-143.

Tacon, A.G.S., 1999. Trends in global quaculture and aquafeed production: 1984 – 1996 highlights, In: Brufau,J., Tacon, A. (Eds.). Feed manufacturing in the Mediterranean region. Recent advances in research and technology, CIHEAM/IAMZ, Zaragora Spain, Vol 37, pp. 107-122.

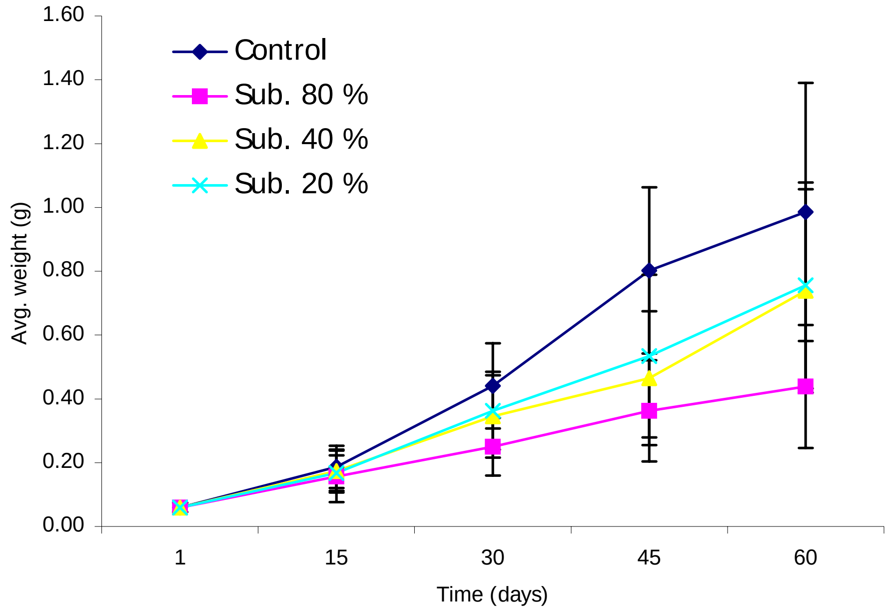
0 Annexes



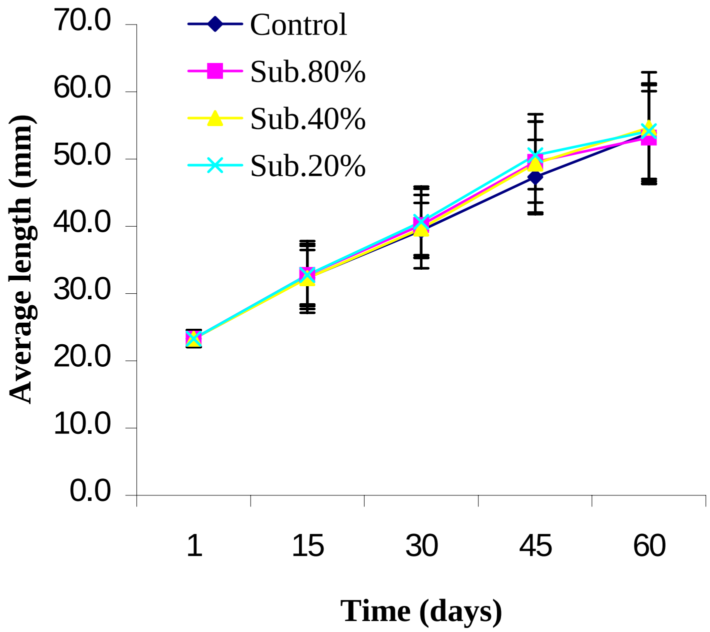
Annex 1: Average survival rate of shrimp after 60 days fed different levels of substitution fish meal protein by PBM and MBM (treatment I: control; treatment II: 80% FM substituted by PBM; treatment III: 40% FM substituted by PBM; treatment IV: 20% FM substituted by PBM; treatment V: 80% FM substituted by MBM; treatment VI: 40% FM substituted by MBM; treatment IV: 20% FM substituted by MBM)



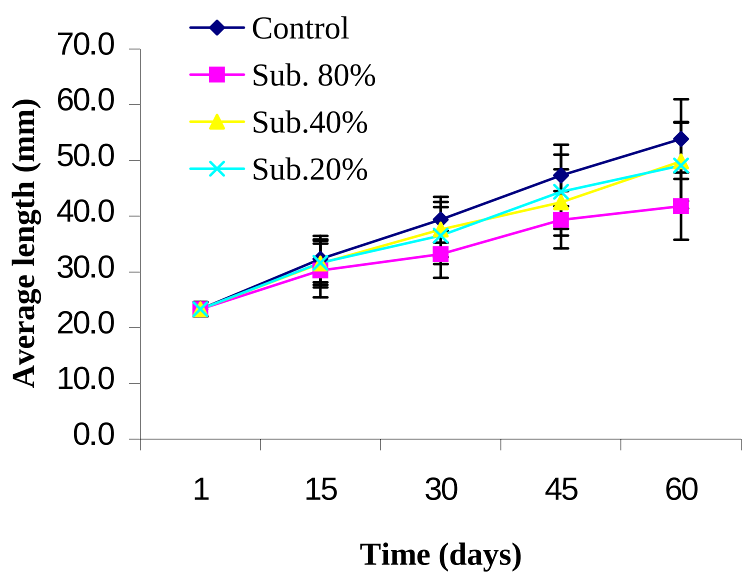
Annex 2: Growth performance of shrimp after 60 days fed different levels of substitution fish meal protein by PBM.



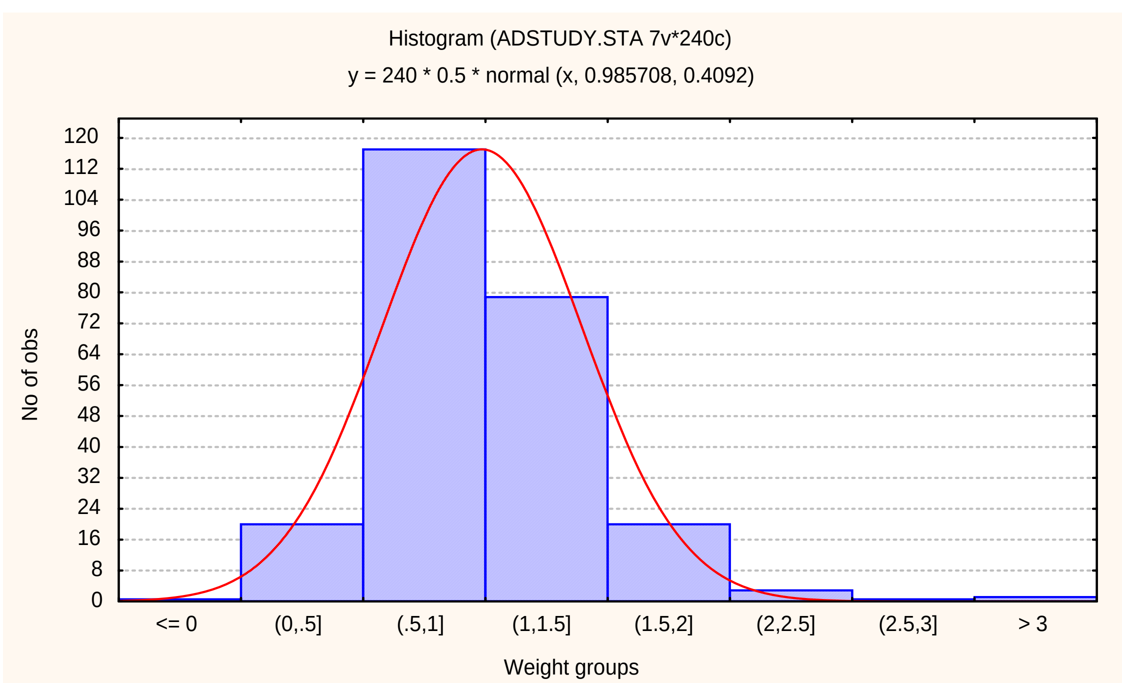
Annex 3: Growth performance of shrimp after 60 days fed different levels of substitution fish meal protein by MBM.



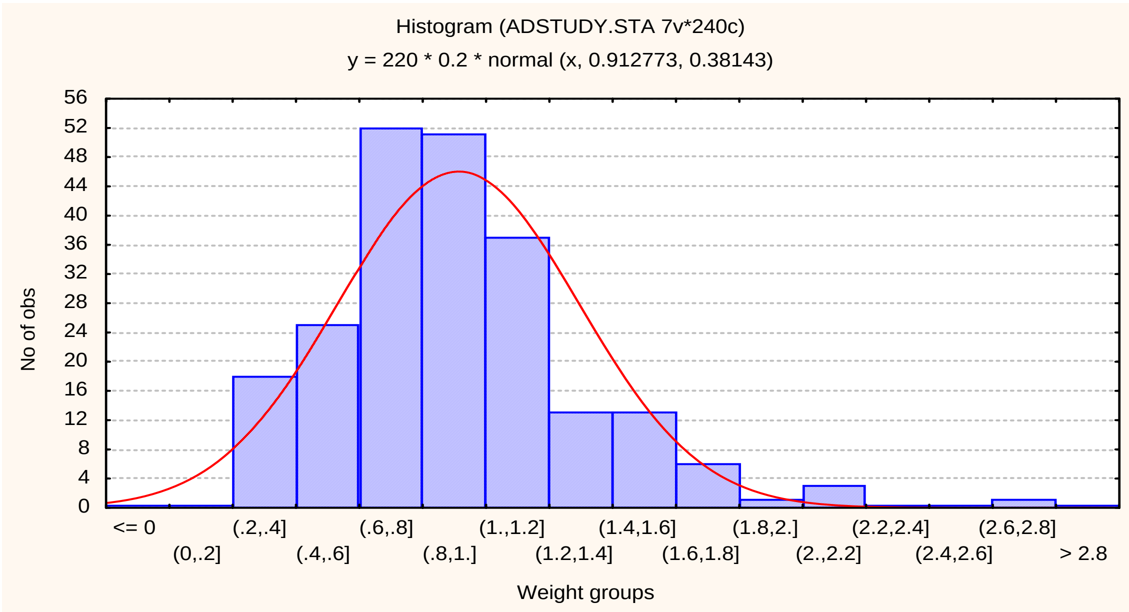
Annex 4: Average length of shrimp after 60 days fed different levels of substitution fish meal protein by PBM



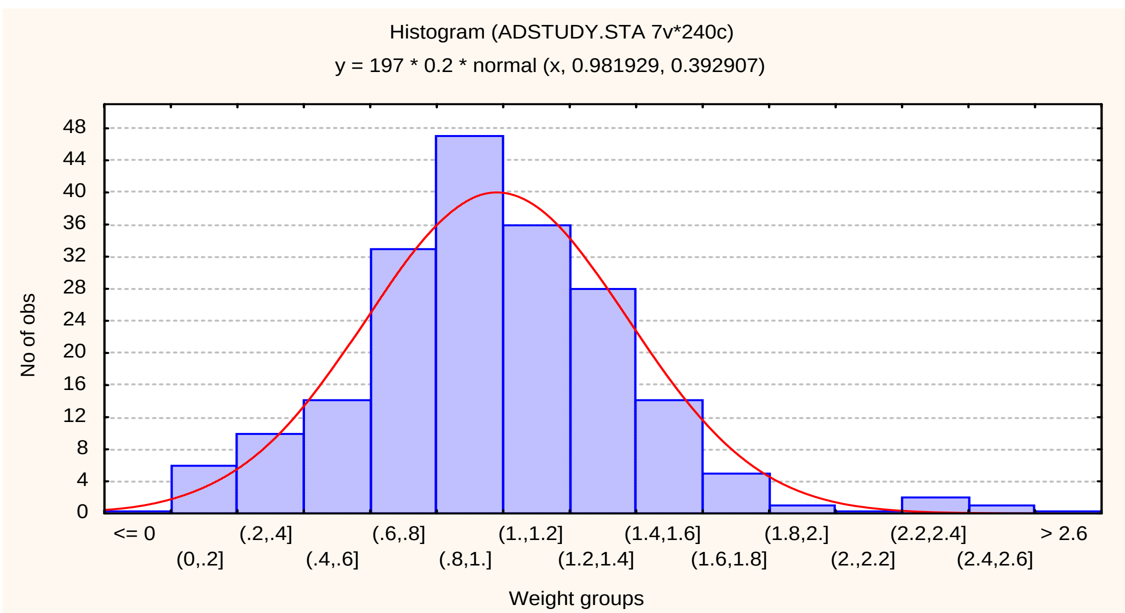
Annex 5: Average length of shrimp after 60 days fed different levels of substitution fish meal protein by MBM.



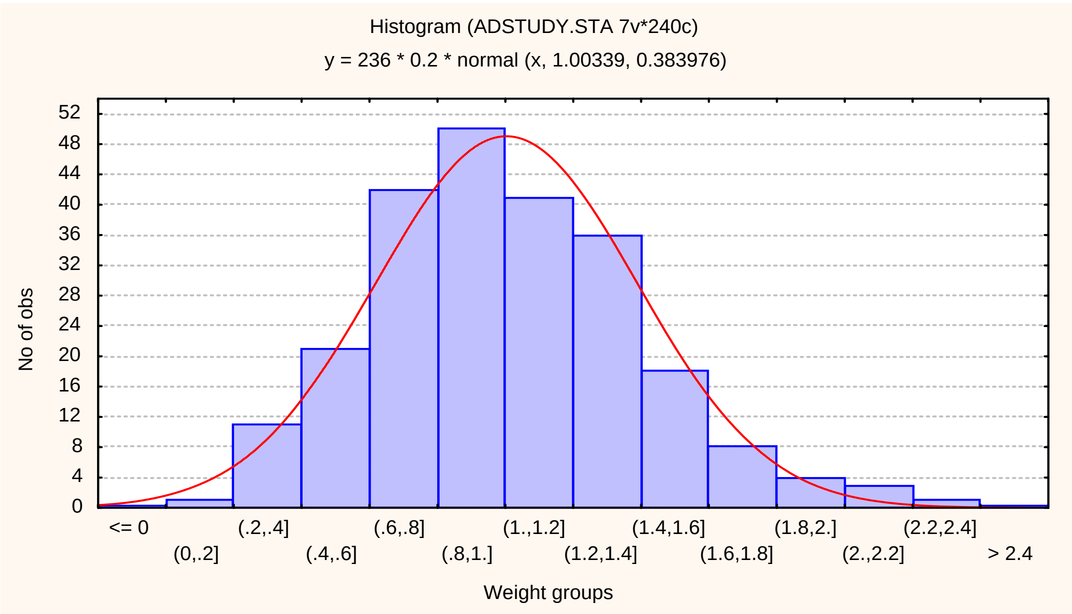
Annex 6: Size distribution of shrimp in treatment I (basal diet) after 60 days



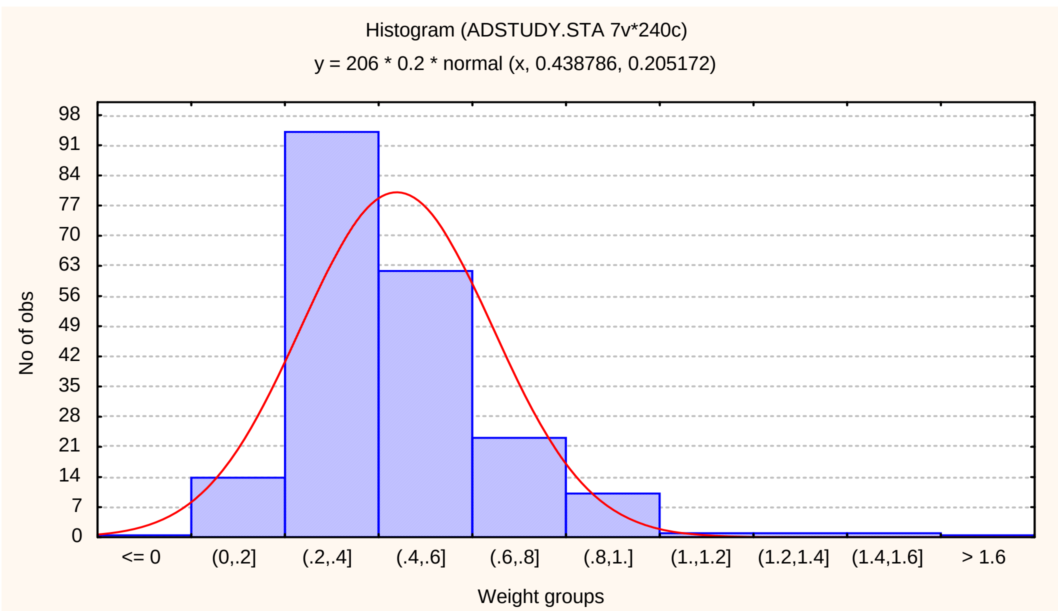
Annex 7: Size distribution of shrimp in treatment II (80 % FM substituted by PBM) after 60 days



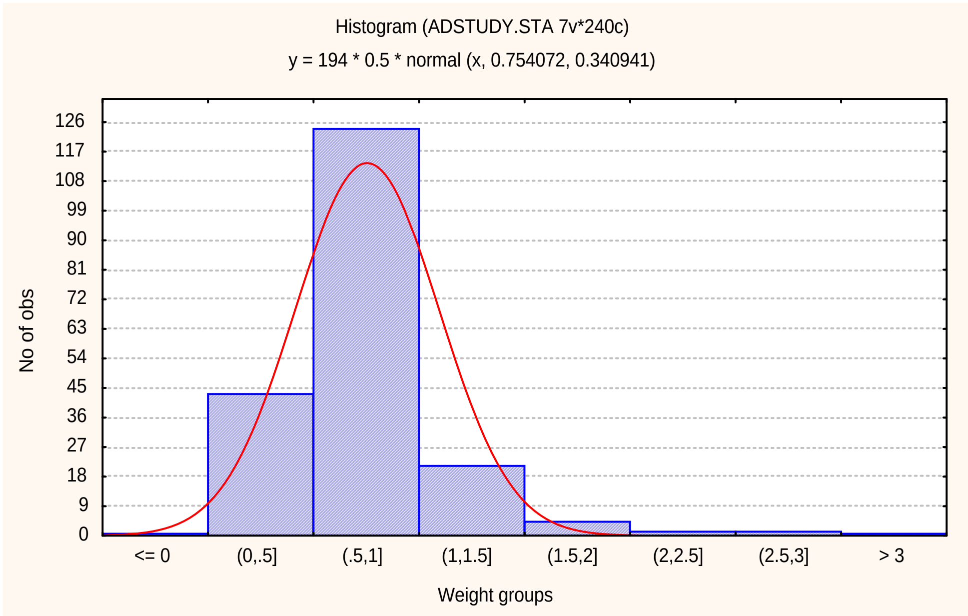
Annex 8: Size distribution of shrimp in treatment III (40 % FM substituted by PBM) after 60 days



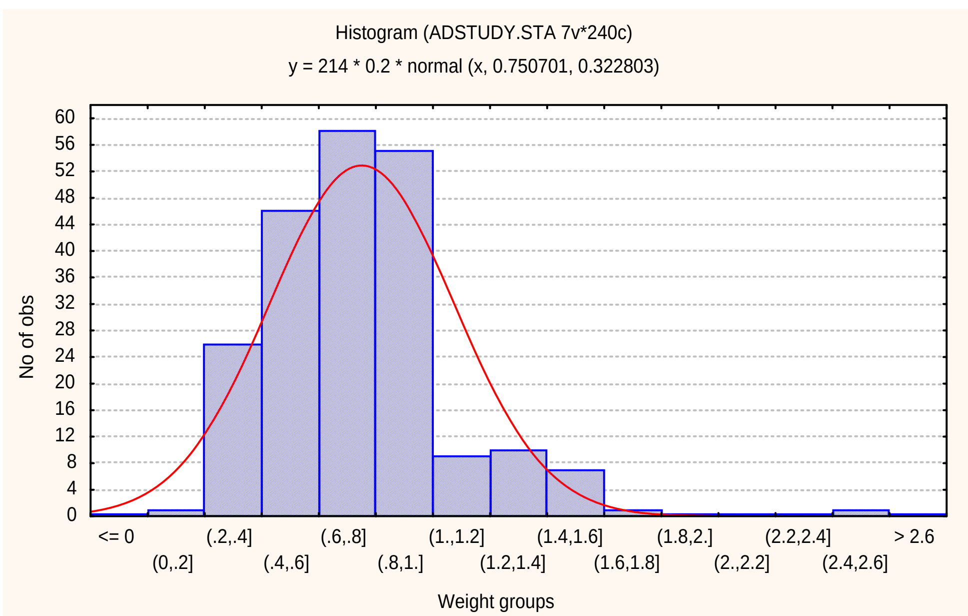
Annex 9: Size distribution of shrimp in treatment IV (20 % FM substituted by PBM) after 60 days



Annex 10: Size distribution of shrimp in treatment V (80 % FM substituted by MBM) after 60 days



Annex 11:Size distribution of shrimp in treatment VI (40 % FM substituted by MBM) after 60 days



Annex 12: Size distribution of shrimp in treatment VII (20 % FM substituted by MBM) after 60 days