Production of soybean meal-based feed and its effect on growth performance of western white shrimp (*Litopenaeus vannamei*) in earthen pond

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Abstract

The effects of two diets, a control diet (commercial feed with 39% crude protein) and an experimental diet (prepared based on 42% soybean meal with 38% crude protein), on growth performance of western white shrimp (*Litopenaeus vannamei*) in six 0.4-ha-earthen ponds (three replications per treatment) with 25 per m^2 density, were investigated. There was no significant difference in final weight (mean final weights were 15.7±0.88 and 15.6±0.52 g for the experimental and control treatments, respectively) between the treatments during the 115 days rearing period. There were no difference in FCR: 1.80±0.08 and 1.76±0.06, protein efficiency: 1.46±0.01 and 1.45±0.05, SGR: 2.38±0.04 and 2.38±0.03, final production: 2853.58±64.14 and 2864.83±168.57 kg/ha and survival rate: 91±1.78, 92±2.41% between experimental and control treatments, respectively ($p>0.05$) but net protein utilization in experimental treatment (17.05±0.38 g) and in the control (11.80±0.26 g) revealed significant differences ($p<0.05$). It is concluded that the experimental feed with 42% soybean meal was more efficient than the commercial feed on some growth parameters of western white shrimp.

Keywords: Plant protein, Western white shrimp, Earthen pond, Growth performance

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Introduction

Determination of the effect of plant-based diet on growth performance of western white shrimp in earthen ponds is very important. Earthen ponds have natural foods such as benthic organisms, phytoplankton and zooplankton, and western white shrimp tend to eat plant protein and detritus; it shows the importance of plant-based diets in cutting shrimp rearing costs (Wyban and Sweeney, 1991). Penaeid shrimps are known as omnivorous organisms, abundantly found in coastal regions, where a high amount of organic detritus is found. Although detritus is not the preferred feed item for all shrimp species, it has been reported that banana shrimp (*Fennero penaeus merguiensis*) feeds on detritus when animal food items are not present (Ojha, 2006). Western white shrimp are known as important species capable of feeding on plant-based feeds (Akiyama[a], 1988; Akiyama, 1990; Swick *et al*., 1995; Mente, 2003) and detritus (Verstraete, 1995).

Soybean meal is the most-commonly-used plant protein in aquaculture, which contains more digestible protein than animal proteins such as fish meal, shrimp meal and squid meal (Akiyama, 1988[b]). It is used as a fish meal alternative (Divakaran *et al*., 2000; Hoseini and Khajepour, 2012; Emdadi *et al*, 2013). Soybean meal is 10, 11 and 17% more digestible than fish meal, squid meal and shrimp meal, respectively (Akiyama, 1988[b]). Also, Mente (2003) reported that soybean meal and fish meal digestibility is 90 and 80.7%, respectively in shrimp. Resistance to oxidation and degradation, and lack of fungi, virus and bacteria are important advantages of soybean meal for shrimp (Swick *et al*., 1995.Wouters *et al*., 2001). The aim of the present study was to investigate the effect of 42% dietary soybean meal incorporation on growth performance of western white shrimp in earthen ponds.

Materials and methods

Experimental diet proximate composition and preparation percentages

Formulation of the diet was performed using Worksheet (Alava, 1996). The proximate compositions of feed ingredients, plant-based diet composition and tested diets are presented in Tabels 1, 2 and 3 respectively.

Water physico-chemical parameters including temperature, dissolved oxygen, turbidity, pH and salinity were measured. The mean (±SD) of the Physico-chemical parameters of water are presented in Table 4.

This study was conducted in 0.4-ha earthen ponds of Research Station of Halleh. Shrimp (post-larvae, 18) with an average weight of 0.008±0.001 g were stocked in the earthen ponds in July (2015) with 25 per m^2 density. The control treatment was fed commercial feeds (4001-4006), whereas, the experimental treatment was offered the experimental plant-based diet.

Table 1: Proximate composition of feed ingredients in the experimental treatments.

Ingredients	Composition%				
	Crude protein	**Crude fat**	**Ash**	**Fiber**	**Moisture**
Fish meal	61.03	14.55	7.1	1.52	8.73
Shrimp meal	55.3	3.16	28	10	8
Wheat meal	13.92	1.53	0.92	2.19	10.88
Soybean meal	48	1.08	19.45	3	8.09
Wheat Gluten	78.93	2.62	1.53	0.39	7.25

Table 2: The plant-based diet composition.

Ingredients of experimental diets (plant group)	Amount (%)
Soybean meal	42
Fish meal	11
Shrimp meal	10
wheat meal	29.5
Fish oil	2
Gluten	2
Soy lecithin	1.5
Vitamin supplements	0.5
Mineral supplements	0.5
Connective	1
Total (%)	100

Table 3: Proximate composition of the tested diets (dry matter basis).

Composition%	Treatment	
	Plant Group	**Control Group**
Crude protein	38	39
Crude fat	6.36	7
Ash	4.58	3
Fiber	12.99	12
Nitrogen Free Extract(NFE)	29.51	29
Moisture	8.49	10

Table 4: Physico-chemical parameters of water (Mean±SD) of the control and experimental ponds during the experiment.

Treatment	Turbidity (cm)	Salinity (ppm)	Depth (cm)	Temperature (^{0}C)		Dissolved oxygen (ppm)		pH	
				Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Plant group	13.1± 40.41^{a}	1.94± 45.56^{a}	3.85± 135.2^{a}	4.01± 27.42^{a}	4.29± 30.88^{a}	0.57± 3.33^{a}	0.7± 7.01^{a}	0.14± 8.23^{a}	0.1 ±8.3^{a}
Control group	9.95± 37.19^{a}	1.27± 45.82^{a}	4.12± 134.5^{a}	0.53± 27.32^{a}	3.52± 30.97^{a}	0.9± 3.39^{a}	0.43± 6.72^{a}	0.13± 8.26^{a}	0.15± 8.3^{a}

Values in the same column different superscripts are significantly different (p<0.05).

A blind feeding program was followed in the first month of rearing; thereafter the shrimps were fed based on body weight. Feeding was controlled using feeding plates.

After 30 days of rearing, the shrimp were fed based on 8% of body weight and the amount decreased to 4% until the termination of the experiment. Fifty shrimp were sampled using cast nets every 10 days to determine mean length and weight. Mean growth rate, FCR, protein efficiency, SGR and net protein utilization (NPU) were calculated (Steffens, 1989). Mean daily growth was calculated, as well (Nour *et al*., 2004). This experiment was conducted based on a completely randomized design and one way ANOVA, and mean comparison was performed using Duncan test at 0.95 confidence limits (α= 0.05).

Results

Proximate composition of the diets

The diets were similar in digestible energy of 350 kcal per 100 g (Sangpradub *et al*., 1994; Wickins and Lee, 2002).

Water temperature, salinity, pH, dissolved oxygen fluctuation and water depth during the study are presented in Figs. 1, 2, 3, 4 and 5 respectively.

Growth performance including final weight, feed intake, FCR, protein efficiency, SGR, daily growth rate and net protein utilization are presented in Table 5.

Carcass proximate compositions are presented in Table 6.

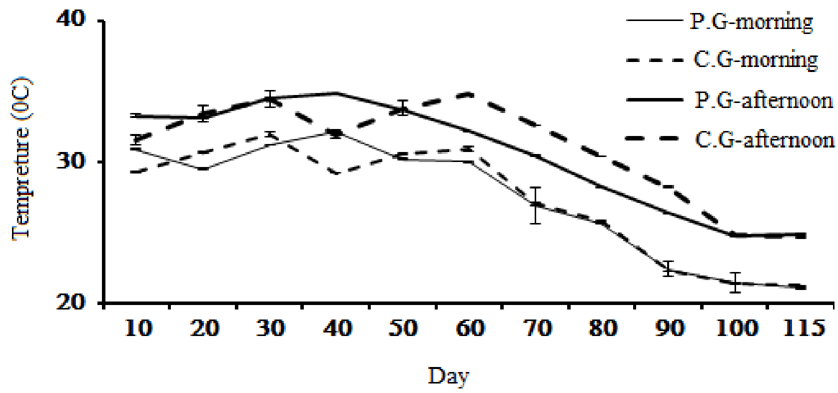

Figure 1: Water temperature (morning and afternoon) fluctuations of the treatments during the study.

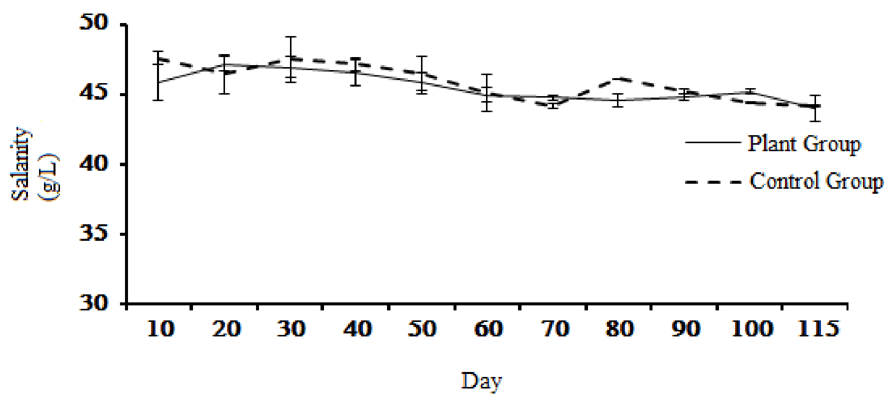

Figure 2: Water salinity fluctuations of the treatments during the study.

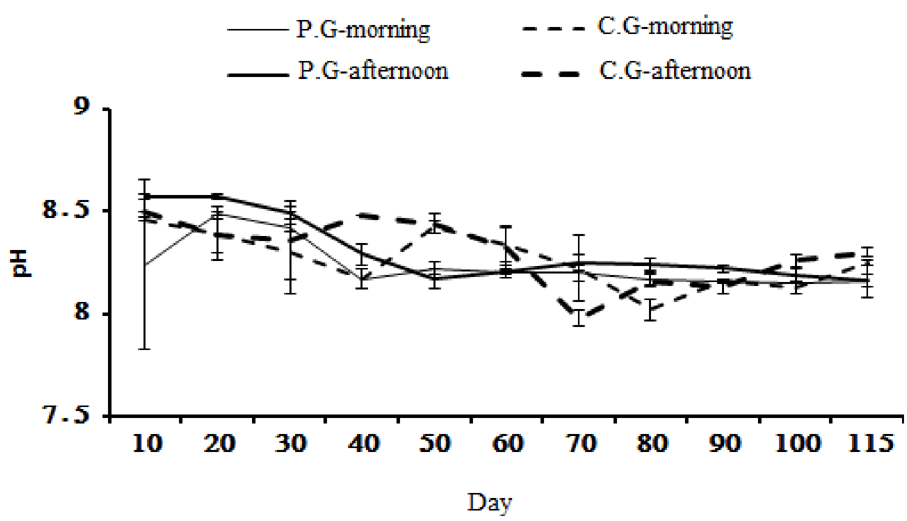

Figure 3: Water pH (morning and afternoon) fluctuations of the treatments during the study.

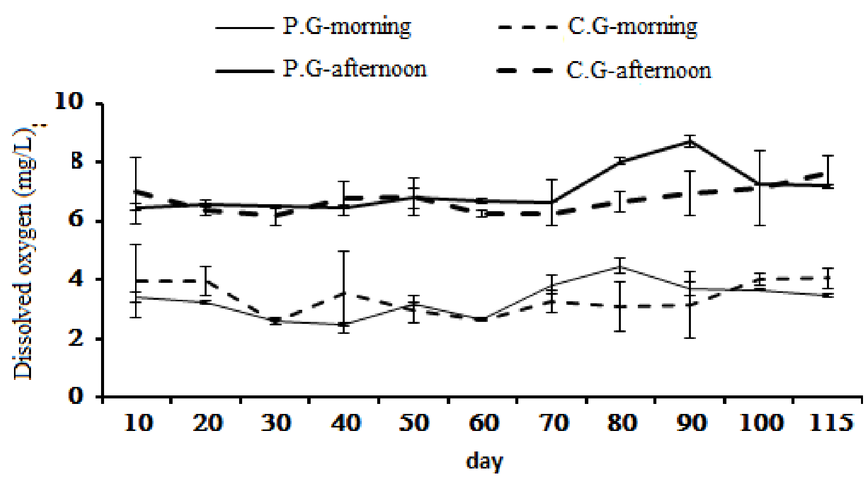

Figure 4: Dissolved oxygen (morning and afternoon) fluctuations in water of the treatments during the study.

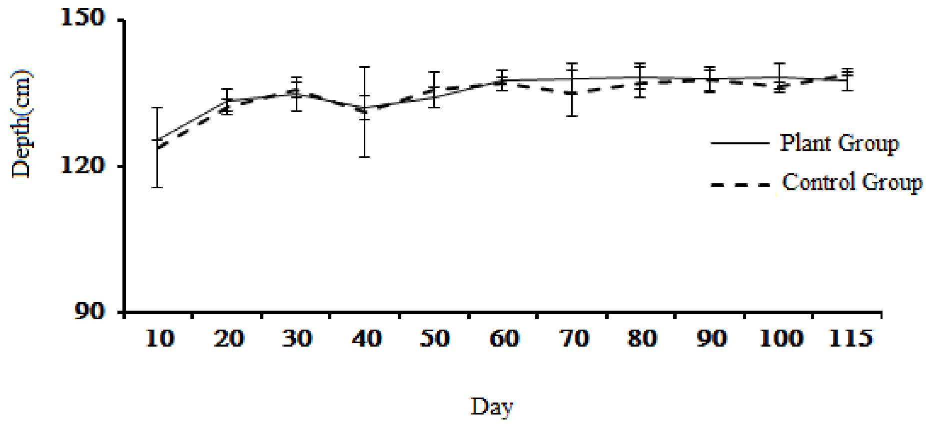

Figure 5: Water depth fluctuations of the treatments during the study.

Table 5: Comparison of growth parameters (mean±SD) of shrimp fed different diets.

Parameters	Treatment	
	Plant Group	**Control Group**
The mean initial weight (g)	0.008^{a}±0.001	0.008^{a} ±0.001
The mean final weight (g)	15.7^{a} ±0.88	15.6^{a} ±0.52
Feed conversion ratio (FCR)	1.8^{a} ±0.08	1.76^{a} ±0.06
Protein efficiency ratio	1.46^{a} ±0.01	1.45^{a} ±0.05
Special growth rate (SGR)	2.38^{a} ±0.04	2.38^{a} ±0.03
Daily weight gain (g/day)	0.136^{a} ±0.007	0.135^{a} ±0.004
Exploitation of purified protein (%)	17.05^{b}±0.38	11.8^{a} ±0.26
Production	2853.5^{a} ±64.14	2864.8^{a} ±95.24
Survival (%)	91^{a} ±1.72	92^{a} ±2.41
Food intake	5144^{a} ±112.23	5055^{a} ±59.77
Breeding period (day)	115	115

Different letters a and b in each row mean significant difference (p<0.05)

Table 6: Comparison of carcass composition of the shrimp (dry matter basis).

Parameters	Treatment	
	Plant Group	**Control Group**
Crude protein	86.68^{a}±0.25	84.92^{b}±0.3
Crude fat	0.5^{a} ±0.19	0.5^{a} ±0.22
Fiber	0	0
Ash	7.2^{a} ±0.32	6.8^{b} ±0.18
Moisture	68.83^{a} ±1.26	64.63^{b} ±1.46

Different letters a and b in each row mean significant difference (p<0.05).

Discussion

Most of the growth indices in the experimental treatment (plant-based diet) were better than those of the control treatment suggesting that a plant-based diet is more suitable than a commercial one in earthen ponds. According to the results of physical factors, dissolved oxygen has been the important factor affecting growth performance. Cornejo *et al*. (2012) have monitored consumption of live and artificial feeds by western white shrimp in 400-m^2 earthen ponds with 20 shrimp per m^2 density. They reported that the shrimp fed 68% live feed and 32% artificial feed in the fertilized ponds; whereas, they fed on 42% live feed and 58% artificial feed in non-fertilized ponds. In addition, pond natural production has several advantages for shrimp. In this case, it has been reported that western white shrimp growth increases in ponds having sufficient algae and suspended solids compared to clear ponds by the factor 1.5-1.9. It has been demonstrated that particles larger than 0.5 mm stimulate shrimp growth (ACE, 2003). These particles probably are covered by bacteria and utilized by the shrimp as feed items. Argue *et al*. (2001) studied the effects of total replacement of dietary (35% crude protein) animal protein with plant protein in white-leg shrimp and found that final weight (8.5±1.8, 10.2±2.3 g) and FCR (2.1±0.3 , 1.9±0.6) in the plant-based diet were significantly better than those in the commercial diet, which is in line with the results of the present study. Conclin (2004) replaced fish meal with up to 100% soybean meal in western white shrimp diets and found that soybean meal inclusion higher than 28% suppressed shrimp growth due to impaired pellet stability. Inclusion of a high level of wheat meal in the diet resulted in higher stability and homogeneity of the pellets in the present study. Also, the role of a binder, feed ingredients, primary grounding and pelletizer type should be considered in feed quality. Cummins *et al*. (2013) studied the effect of 100% fish meal replacement with soybean meal in western white shrimp during 8 weeks. They reported that total fish meal replacement with soybean meal deteriorates shrimp growth performance. Yang *et al*. (2015) investigated the effect of fish meal replacement with soybean meal in western white shrimp diet containing 40% crude protein and 30% fish meal. They reported that soybean meal could replace fish meal up to 20% without any significant effects on the shrimp growth. Overall, it is concluded that plant proteins such as soybean meal have positive effects on shrimp growth performance.

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