Khulna University Studies Volume 21(1): 178-186: 2024

ORIGINAL ARTICLE

LIFE SCIENCE

EFFECT OF DIETARY REPLACEMENT OF SOYBEAN MEAL WITH SHRIMP HEAD MEAL (*Penaeus monodon*) ON PRODUCTION PERFORMANCE OF LAYING HENS

Sarder Safiqul Islam*, Md. Bashirul Islam, Chaitanya Paul, Md. Mustajabur Rahman and Dhiman Mondol

Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh

KUS: 1203: 04052024

Manuscript submitted: May 04, 2024 Accepted: June 11, 2024

Abstract

The study aimed to find out how the performance of laying hens was affected when different levels of shrimp head meal (SHM) were added to the poultry diet in place of soybean meal (SBM). Five groups of Hisex White laying hens, aged 19 to 40 weeks, were fed a control corn-soybean layer diet and diets where SBM was replaced with SHM at level of 0, 25, 50, 75 and 100%. The control group received a diet without SBM replacement. Chickens fed diet at 25% SBM replacement by SHM recorded significantly highest egg production at 23-25, 29 and 31 weeks of age. Additionally, this group exhibited the lowest feed conversion ratio (FCR) at 19, 20, 23, 25, 29 and 31 weeks of age. Feed cost per egg production was highest in the control group and lowest in the 100% replacement at 27-29, and 38 weeks of age. The findings suggest that using unconventional feed resources like SHM, a rich source of crude protein, can reduce production costs and be a viable alternative to SBM in poultry diets.

Keywords: Alternative feed resources, Laying hens, Poultry diet, Shrimp head meal, Soybean meal

Introduction

Bangladesh's poultry industry holds significant potential, exhibiting one of the fastest growth rates among all sectors. The future demand for poultry products is expected to increase due to rapid population growth and urbanization. The primary barrier preventing poultry farming from developing and expanding is still feed costs, which make around 70–80 percent of the entire cost of producing chicken eggs and meat (Samuel Olugbenga et al., 2015). The least cost ration is prepared due to the high cost and scarcity of poultry feed, particularly protein sources. The majority of feed cost can be attributed to protein concentrates such as fishmeal, groundnut cake, and soybean meal. The cost of these traditional protein sources has increased where it is no longer cost-effective to utilize them in chicken diets, which has forced researchers to look for low-cost protein concentrate alternatives (Adeyemi et al., 2013). A great deal of research was done in the search for alternatives to soybean meal in poultry diets. Poultry nutritionists have therefore been experimenting with various unconventional feed types in an effort to reduce the cost of poultry rations. These include rubber seed meal (Ijaiya et al., 2011), shrimp wastes (Gernat, 2001), rumen ingesta, kitchen wastes, banana leaf meal, and leucaena leaf meal, oilseed meals like castor oil seed (Ani and Okorie, 2009) etc.

An estimated 248.8 metric tons of shrimp waste, or 37% of the total shrimp mass received by the sector, are produced daily by shrimp processing plants in Bangladesh's coastal districts (Hossain et al., 2018). This by-product of shrimp processing plants has the ability to partially or completely replace traditional protein sources in layer rations, such as fish meal, meat and bone meal, and soybean meal (SBM). The black tiger shrimp (*Penaeus monodon*) head meal contains an average of 52.3% crude protein, 6.4% ether extract, 10.8% crude fiber, and 20.4% crude ash (Rahman and Koh, 2014). A previous study showed that there was no significant impact on egg production when shrimp waste was used in place of SBM in layer diet, but lowest feed conversion efficiency was accompanied by increased feed consumption with higher shrimp waste levels (Gernat, 2001). Another study found that increased SHM levels in broiler diets led to reduced feed consumption and decreased body weight gain. (Rahman and Koh, 2016). In light of these, the current study was carried out to determine the effects of replacing different levels of SBM with SHM for in the diet on the production performance of laying hens.

*Corresponding author: <sardersislam@at.ku.ac.bd>

DOI: https://doi.org/10.53808/KUS.2024.21.01.1203-ls

Materials and Method

Site and design of experiment

Dr. Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Khulna, Bangladesh, was the site of the experiment. Out of five hybrids, the Hisex White layer hybrid was said to perform the best, hence it was chosen to carry out the experiment (Islam et al., 2013). The design of the feeding experiment was based on randomized complete block design (RCBD). The five treatment groups of experimental birds were randomly assigned to five distinct diets containing varying amounts of shrimp head meal (SHM). Three were three replications for each treatment and number of birds for each replication was twenty. As a result, 60 birds were maintained for each treatment, for a total of 300 birds across five treatments. The feeding experiment was continued from the 19 to 40 week of hen age.

Bio-security measurement

The proper biosecurity precautions were implemented during the experimental period. The researchers and poultry attendants changed their shoes and sprayed a disinfectant on their feet before going into the shed. No wild birds, predators, rats, or other rodents were permitted, and visitor access was strictly limited.

Management practices

The shed used to keep the experimental birds had a slate floor and was properly ventilated. Feeders, waterers, and the floor were all routinely cleaned and disinfected. Using an electrical debeaker, the experimental birds were debeaked early, at 70 days of age. It was appropriately maintained to have 16 hours of light and 8 hours of darkness from the 19th week to the 40th week of laying hens. At every two months intervals, a killed vaccine called Imopest was given to prevent Newcastle disease, and after every five months, a live vaccine called Avenue was given to prevent the disease. During the laying season, the fowl cholera vaccine was administered. As advised by the vaccine producers, vaccinations against all infectious diseases, including egg drop syndrome, infectious bursal disease, Marek's, fowl pox, salmonella, infectious laryngotracheitis, and fowl cholera, were administered early (before the age of eighteen weeks). Medications to prevent coccidiosis and anthelmintics were regularly given. Every bird had the same housing conditions and access to the same management.

Shrimp head meal (SHM) processing and proximate analysis

From shrimp processing plants, black tiger shrimp (*Penaeus monodon*) heads were collected. Shrimp heads were left to sundry for three days following their arrival at the experimental site. A grinding machine was used to smash the shrimp heads once they had dried. The proximate components of shrimp head meal (SHM) were measured using the AOAC (1990) technique in the Animal Husbandry Laboratory of the Agrotechnology Discipline at Khulna University in Bangladesh. The components included dry matter, crude protein, crude fiber, ether extract, and ash contents. The proximate composition of the heads of two main shrimp species, namely the black tiger (*Penaeus monodon*) and the giant freshwater prawn (*Macrobrachium rosenbergii*), was determined individually (**Table 1**).

Table 1. Proximate composition of shrimp head meal (% on DM basis)

Proximate components	Shrimp species	
	Black tiger shrimp (*Penaeus monodon*)	Giant freshwater prawn (*Macrobrachium rosenbergii*)
Moisture (% on fresh basis)	77.39	54.61
Dry matter (DM)	22.61	45.39
Crude protein (CP)	52.26	32.34
Total ash (TA)	21.69	17.51
Acid insoluble ash (AIA)	0.59	0.62
Crude fibre (CF)	3.20	4.10
Ether extract (EE)	5.78	24.23

Ration computation and feeding schedule

Following weighing, the necessary quantity of feed additives and ingredients were thoroughly combined in a feed mixing machine. The experimental laying hens were fed two different types of layer rations: layer phase-1 (19 to 30 weeks of age) and layer phase 2 (31 to 40 weeks of age) (**Table 2** and **Table 3**). The major protein source (SBM) in the experimental ration was substituted with SHM at 0, 25, 50, 75, and 100%, respectively. The amounts of the other ingredients in the five experimental rations remained constant. Feed and water were given to the experimental flocks of chickens twice a day, at 7.30 am and 4.00 pm. An isocaloric diet was given to the chickens in every treatment group.

Table 2. Composition of experimental diets (kg 100 kg^{-1}) for laying hens at 19–30 weeks of age (phase –1)

Feed ingredients (Kg 100Kg^{-1})	Rate of replacement of SBM by SHM (%)				
	0	25	50	75	100
Maize (*Zea mays*)	50.00	50.00	50.00	50.00	50.00
Rice polish (*Oryza sativa*)	8.90	8.90	8.90	8.90	8.90
Wheat bran (*Triticum aestivum*)	4.000	4.00	4.00	4.00	4.00
Soybean meal	22.00	16.50	11.00	5.50	00
Shrimp head meal	00	5.50	11.00	16.50	22.00
Protein concentrate	5.00	5.00	5.00	5.00	5.00
Limestone	9.00	9.00	9.00	9.00	9.00
Ascovit poultry VM (vitamin)	0.125	0.125	0.125	0.125	0.125
Common salt	0.200	0.200	0.200	0.200	0.200
DL-methionine	0.125	0.125	0.125	0.125	0.125
ADM - lysine	0.050	0.050	0.050	0.050	0.050
Sodium bi carbonate	0.050	0.050	0.050	0.050	0.050
Choline chloride	0.100	0.100	0.100	0.100	0.100
Klinofeed plus (Mycotoxin binder)	0.200	0.200	0.200	0.200	0.200
Rovabio®Max (Enzyme)	0.020	0.020	0.020	0.020	0.020
Bioacid (anti-salmonela)	0.200	0.200	0.200	0.200	0.200
Hedox dry (Antioxidant)	0.020	0.020	0.020	0.020	0.020
Probiolac (probiotics)	0.010	0.010	0.010	0.010	0.010
Total	100	100	100	100	100
Energy contents (Kcal/kg)	2734.00	2734.20	2734.40	2734.60	2734.80
Protein contents (g/100g)	18.86	19.03	19.20	19.37	19.54

SBM= Soybean meal; SHM= Shrimp head meal

Table 3. Feed composition (kg 100 kg-1) for laying chickens between the ages of 31 and 40 weeks (phase -2)

Feed ingredients (Kg 100Kg^{-1})	Rate of replacement of SBM by SHM (%)				
	0	25	50	75	100
Maize (*Zea mays*)	56.00	56.00	56.00	56.00	56.00
Rice polish (*Oryza sativa*)	11.37	11.37	11.37	11.37	11.37
Soybean meal	18.00	13.50	9.00	4.50	00
Shrimp head meal	00	4.50	9.00	13.50	18.00
Protein concentrate	5.00	5.00	5.00	5.00	5.00
Limestone	8.50	8.50	8.50	8.50	8.50
Ascovit poultry VM (vitamin)	0.120	0.120	0.120	0.120	0.120
Common salt	0.200	0.200	0.200	0.200	0.200
DL- Methionine	0.125	0.125	0.125	0.125	0.125
ADM - Lysine	0.075	0.075	0.075	0.075	0.075
Sodium bi carbonate	0.060	0.060	0.060	0.060	0.060
Cholin chloride	0.100	0.100	0.100	0.100	0.100
Klinofeed plus (Mycotoxin binder)	0.200	0.200	0.200	0.200	0.200
Rovabio®Max (Enzyme)	0.020	0.020	0.020	0.020	0.020
Bioacid (anti-salmonela)	0.200	0.200	0.200	0.200	0.200
Hedox dry (Antioxidant)	0.020	0.020	0.020	0.020	0.020
Probaiolac (probiotics)	0.010	0.010	0.010	0.010	0.010
Total amount	100.00	100.00	100.00	100.00	100.00
Energy contents (Kcal/kg)	2850	2850.20	2850.40	2850.60	2850.80
Protein contents (g/100g)	17.30	17.47	17.64	17.81	17.98

SBM=Soybean meal; SHM=Shrimp head meal

Collection of data and statistical analyses

Eggs were collected from each pen three times daily at 10 am, 1 pm and 4 pm. Data on egg production, feed intake and number of dead birds were recorded daily from each pen. Egg weight data from each pen were recorded weekly and body weight fortnightly. Egg weight data were collected from the average weight of at least 10 eggs and laying hen body weight data from the average weight of at least 5 birds from each pen. Analysis was done with the help of computer program 'MSTAT-C'. Least significant difference (LSD) was performed to compare treatment means for various parameters.

Each pen had three egg collections each day, at 10 a.m., 1 p.m., and 4 p.m. Every day, the number of dead birds, feed consumption, and egg production were recorded from every pen. Every week, the weight of the eggs in each pen was recorded, and every two weeks, the body weight. Data on egg weight was collected by averaging the weight of a minimum of 10 eggs, while information on laying hen body weight was collected by averaging the weight of a minimum of 5 birds each pen. With the aid of the computer program "MSTAT-C," analysis was done. The treatment means for different parameters were compared using the least significant difference (LSD) method.

Results and Discussion

Feed intake (g bird^{-1} day^{-1})

Table 4 displays the daily feed intake (g bird^{-1}) of laying chickens under various dietary regimens. In most age categories, feed intake did not vary significantly due to SBM replacement of laying hen's rations with different levels of SHM. However, significant differences in feed intake were observed at 19, 31, 33, 36, 37 and 39 weeks of age for different rates of SBM replacement with SHM. At the 31, 36, and 37 weeks of age, 100% replacement recorded the significantly highest intake of 119.33, 117.67, and 117.67 g day^{-1}, respectively. This suggests that laying hen intake rose as the amount of SHM in the diet increased, which is consistent with the findings of Gernat (2001). He noticed that the replacement of SBM in the chicken ration by shrimp waste resulted in a significant ($p<0.01$) increase in feed consumption. Similarly, Ingweye et al. (2008) observed that broiler feed intake increased as shrimp and fish waste meal replaced SBM at increasing rates. According to Agunbiade et al. (2004), the sweet aroma that shrimp waste meal imparts on the ration may be the cause of the birds' increased feed intake. Rosenfeld et al. (1997), however, did not discover a substantial impact of shrimp meal on feed intake in broilers.

Table 4. Daily feed consumption (g bird^{-1}) of laying chickens at several ages with different substitution levels

Age of laying hens (week)	Rate of replacement of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	82.73^{a}	78.37^{b}	76.33^{bc}	75.87^{bc}	73.97^{c}	3.49	**
20	90.30	86.77	81.97	86.13	85.57	6.34	NS
21	98.50	97.77	100.20	96.20	95.03	5.06	NS
22	100.30	99.50	101.90	96.43	96.10	4.23	NS
23	109.33	111.33	108.67	105.67	101.33	5.74	NS
24	114.33	115.67	112.33	108.67	110.00	5.99	NS
25	113.67	113.33	114.00	114.33	113.67	3.85	NS
26	115.67	114.67	116.33	116.00	114.33	4.47	NS
27	119.00	119.33	119.00	116.00	117.00	3.16	NS
28	118.67	119.00	121.67	120.00	119.33	3.73	NS
29	120.00	120.33	121.00	120.33	120.67	3.59	NS
30	112.33	111.67	113.67	112.67	112.00	4.46	NS
31	115.00^{b}	117.33^{ab}	119.00^{a}	118.00^{a}	119.33^{a}	2.62	*
32	118.33	113.33	117.00	117.67	117.33	3.58	NS
33	121.33^{a}	114.33^{b}	117.33^{b}	114.67^{b}	115.33^{b}	3.58	*
34	119.67	120.67	116.67	118.67	120.67	2.98	NS
35	119.33	117.67	121.67	120.00	120.67	2.71	NS
36	115.67^{ab}	111.33^{c}	113.67^{bc}	114.33a^{bc}	117.67^{a}	3.62	*
37	116.00^{b}	112.33^{c}	110.00^{d}	113.33^{c}	117.67^{a}	1.38	***
38	113.67	110.33	110.67	110.33	113.33	4.29	NS
39	112.00^{bc}	114.33^{a}	112.33^{bc}	113.33^{ab}	111.33^{c}	1.59	*
40	112.00	113.00	110.33	111.00	111.33	2.19	NS

*NS=not-significant ($p>0.05$); * $p<0.05$; ** $p<0.01$; *** $p<0.001$*
$^{a,\ b,\ c}$ Mean with different superscripts in the same row are significantly different.
SBM=Soybean meal; SHM=Shrimp head meal

Egg production

Table 5 displays the percentage of eggs produced by laying chickens under various dietary regimens. At 19, 20, 21, 22, 25, 29 and 31 weeks of age, the egg production varied significantly across feed groups; however, the mean difference between age groups at rest was not significant ($p>0.05$). At 23, 24, 25, 29, and 31 weeks of age, the maximum egg production was recorded as 94.10, 95.33, 95.27, 97.43, and 92.40%, respectively, in the group of laying hens fed a diet where SHM replaced SBM at a rate of 25%. The aforementioned age groups showed a gradual decline in egg production as the amount of SHM in their diets increased. This could be because laying hens produce fewer eggs when their rations are less digestible, which is caused by higher fiber content in SHM (**Table 1**). At 23-25, 29, and 31 weeks of age, birds fed a diet with a 25% replacement rate produced considerably more eggs than birds fed a control group or any other diet group. This suggests that a 25% substitution rate of SHM for SBM was appropriate for egg production. Contrary to the current findings, Gernat (2001) revealed that shrimp waste could replace SBM in layer diets at a significantly higher level without negatively affecting layer performance.

Table 5. Egg production (%) of laying hens at different ages with varying substitution levels

Age of laying hens (week)	Rate of replacement of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	23.53^{a}	19.30^{ab}	15.97^{bc}	12.01^{cd}	5.96^{d}	6.39	**
20	50.67^{a}	46.20^{a}	33.47^{ab}	35.33^{ab}	22.97^{b}	17.74	*
21	57.73	71.53	65.10	62.13	50.97	33.29	NS
22	88.23^{a}	87.67^{a}	86.40^{a}	80.73^{a}	69.73^{b}	7.95	**
23	92.13^{a}	94.10^{a}	91.63^{a}	82.90^{b}	80.17^{b}	7.67	**
24	91.90^{a}	95.33^{a}	93.57^{a}	82.33^{b}	85.40^{b}	6.26	**
25	93.30^{a}	95.27^{a}	94.10^{a}	87.57^{b}	86.83^{b}	5.17	*
26	92.33	94.40	92.40	87.30	86.93	6.14	NS
27	95.17	95.27	92.90	89.00	93.83	5.81	NS
28	92.80	93.87	93.13	91.57	94.10	5.56	NS
29	93.77^{abc}	97.43^{a}	94.93^{ab}	92.87^{bc}	90.03^{c}	3.71	*
30	93.77	94.70	93.17	88.77	85.27	10.17	NS
31	89.27^{a}	92.40^{a}	90.63^{a}	89.33^{a}	82.13^{b}	6.65	*
32	90.90	90.40	90.13	88.23	88.83	9.09	NS
33	91.87	90.17	90.33	78.73	87.00	11.34	NS
34	87.57	91.13	84.20	80.00	81.10	10.04	NS
35	88.77	88.90	88.53	80.70	82.67	10.38	NS
36	86.73	85.97	91.13	82.47	85.73	9.68	NS
37	84.03	82.80	88.77	85.27	81.73	9.51	NS
38	87.13	83.77	86.97	81.80	85.00	6.36	NS
39	85.93	79.37	85.17	80.20	78.07	6.36	NS
40	79.43	72.10	75.83	81.33	69.60	8.94	NS

*NS=not-significant (p>0.05); * p<0.05; ** p<0.01*

^{a,b,c} Mean with different superscripts in the same row are significantly different. SBM=Soybean meal; SHM=Shrimp head meal; LSD = Least significant difference.

Body weight (g bird^{-1})

The laying hens' body weight gain under various dietary treatments only showed significant differences at 19 and 23 weeks of age. At 100% substitution of SHM for SBM, the diet group's lowest body weights were found to be 1173.33g and 1313.33g bird^{-1}, respectively for 19 and 23 weeks of age (Table 6). It suggests that the complete replacement of SBM was not appropriate for the laying hens' body weight gain. According to Ingweye et al. (2008), broiler body weight increased to its maximum when shrimp and fish waste meal were substituted for 25% of SBM. In a similar vein, Oduguwa et al. (2004) found that using shrimp waste in place of fish and soybean meals entirely was not ideal for improving the growth of Anak broilers. However, there was no significant difference (p>0.05) in the body weight gain of laying hens among feed groups for the remaining age groups. This outcome is consistent with the observations of Okoye et al. (2005) that there was no discernible variation in the weight of broiler chickens fed shrimp waste feed during the finisher period. In contrast, Rosenfeld et al. (1997) discovered that treatments where broiler shrimp meal was introduced at a 100% substitution for soybean meal resulted in considerably increased (p<0.01) body weight at 21, 28, 35, and 42 days of age. In contrast to the current findings, Aktar et al. (2012) showed improved weight gain when shrimp and marine waste were substituted for fish meal in broiler diets.

Table 6. Body weight (g $bird^{-1}$) of laying hens at different ages with varying replacement levels

Age of laying hens (week)	Rate of replacement of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	1366.67^{a}	1366.67^{a}	1250.00^{ab}	1333.33^{a}	1173.33^{b}	113.3	*
21	1396.67	1388.33	1386.67	1583.33	1435.00	149.9	NS
23	1400.00^{b}	1413.33^{b}	1438.33^{b}	1521.67^{a}	1313.33^{c}	74.9	**
25	1480.00	1535.00	1505.00	1506.67	1470.00	81.2	NS
27	1561.67	1546.67	1530.00	1585.00	1545.00	105.1	NS
29	1673.33	1640.00	1608.33	1666.67	1696.67	57.4	NS
31	1723.33	1590.00	1608.33	1588.33	1546.67	147.1	NS
33	1680.00	1686.67	1615.00	1563.33	1595.00	119.5	NS
35	1663.33	1633.33	1691.67	1605.00	1600.00	138.9	NS
37	1676.67	1553.33	1516.67	1553.33	1533.33	118.3	NS
39	1653.33	1566.67	1583.33	1580.00	1573.33	118.3	NS

*NS=not-significant (p>0.05); * p<0.05; ** p<0.01*
a, b, c Mean with different superscripts in the same row are significantly different.
SBM=Soybean meal; SHM=Shrimp head meal

Egg weight (g egg-1)

Significant differences in the egg weight were found from 19 to 31 weeks and 33 weeks of bird age (**Table 7**). The diet group with full replacement had the lowest egg weight at 21, 22, and 25 to 30 weeks of age, whereas the control group (no SBM replacement) had the highest egg weight. At 19, 20, 23 and 24 weeks of age, egg weight was the highest in diet group with 25% replacement of SBM by SHM and lowest in diet group with 100% replacement of SBM by SHM. On the other hand, the mean egg weight of the remaining age groups was differed significantly (p>0.05) among different ration groups.

Table 7. Egg weights (g egg^{-1}) of laying hens at different ages with varying replacement levels

Age of laying hens (week)	Replacement rate of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	44.57^{a}	45.87^{a}	43.40^{a}	44.70^{a}	44.50^{b}	20.69	*
20	45.63^{ab}	47.17^{a}	45.77^{ab}	46.10^{a}	44.23^{b}	1.71	*
21	50.80^{a}	50.13^{ab}	48.73^{c}	49.40^{bc}	46.90^{d}	1.25	***
22	51.50^{a}	50.30^{b}	50.23^{b}	49.60^{b}	47.33^{c}	1.13	***
23	53.70^{a}	54.07^{a}	52.23^{a}	50.10^{b}	48.77^{b}	1.79	***
24	54.57^{a}	54.73^{a}	53.63^{a}	53.20^{a}	50.87^{b}	1.81	**
25	55.40^{a}	54.83^{a}	55.13^{a}	54.70^{a}	52.97^{a}	1.23	*
26	56.03^{a}	55.93^{a}	54.73^{b}	54.53^{b}	54.47^{b}	0.97	*
27	57.50^{a}	56.80^{ab}	56.33^{abc}	55.40^{bc}	55.13^{c}	1.50	*
28	58.20^{a}	57.23^{ab}	57.17^{b}	56.27^{c}	55.57^{c}	0.99	**
29	58.30^{a}	57.70^{ab}	57.37^{ab}	57.07^{b}	55.87^{c}	1.02	**
30	58.20^{a}	57.43^{a}	57.60^{a}	57.23^{a}	55.97^{b}	1.01	**
31	58.27^{a}	57.80^{a}	58.70^{a}	57.90^{a}	56.47^{b}	1.18	*
32	57.67	57.17	57.87	56.93	57.67	0.87	NS
33	57.63^{a}	57.87^{a}	58.87^{a}	57.07^{ab}	55.77^{b}	1.73	*
34	58.07	57.13	58.73	57.27	56.97	1.51	NS
35	57.97	57.47	58.57	57.97	57.60	1.15	NS
36	58.00	57.70	59.10	57.87	57.67	1.15	NS
37	58.27	57.70	58.67	57.60	57.33	1.03	NS
38	59.20	58.67	58.67	59.33	58.43	0.77	NS
39	59.70	59.37	59.43	60.00	59.80	0.82	NS
40	60.23	59.43	59.57	59.90	59.93	0.88	NS

*NS=not-significant (p>0.05); * p<0.05; ** p<0.01; *** p<0.001*
a, b, c Mean with different superscripts in the same row are significantly different.
SBM=Soybean meal, SHM=Shrimp head meal

Feed conversion ratio (FCR)

Table 8 displays the feed conversion ratio (weight of feed intake/weight of egg mass) of laying chickens receiving various dietary regimens. Significantly the lowest FCR value was recorded in the diet group at 25% replacement and the highest at 100% SBM replacement by SHM at 20, 23, 25, 29 and 31 weeks of age. This indicates that feed utilization efficiency decreases during complete replacement of SBM by SHM and replacement at 25% ensures maximum utilization. Similar to this, Ingweye et al. (2008) noted increased feed utilization efficiency as a result of 25% shrimp and fish waste meal substitution in broiler rations in place of SBM. According to Oduguwa et al. (2004), it is not appropriate to feed Anak broilers with good feeding efficiency if fish meal and soybean meal are entirely replaced with shrimp waste meal. The lowest FCR of 2.22 and 2.19, respectively, was recorded in the control group at 22 and 27 weeks of age compared to other diet groups. However, among diet groups of laying hens of the majority of ages (21, 24, 26, 28, 30, and 32 to 40 weeks old), there was no significant (p>0.05) variation in FCR.

Table 8. Feed conversion ratio for laying hens of different ages with varying replacement levels

Age of laying hens (week)	Rate of replacement of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	8.18^{b}	9.33^{b}	11.20^{ab}	14.37^{a}	13.47^{a}	3.61	*
20	4.14^{b}	4.01^{b}	5.41^{b}	5.77^{ab}	8.49^{a}	2.77	*
21	5.06	2.77	3.23	3.20	4.09	3.85	NS
22	2.22^{b}	2.27^{b}	2.36^{b}	2.41^{b}	2.92^{a}	0.30	**
23	2.22^{b}	2.20^{b}	2.29^{b}	2.57^{a}	2.61^{a}	0.27	*
24	2.29	2.23	2.25	2.51	2.55	0.27	NS
25	2.21^{b}	2.17^{b}	2.21^{b}	2.40^{a}	2.48^{a}	0.15	**
26	2.24	2.18	2.31	2.44	2.42	0.21	NS
27	2.19^{b}	2.21^{ab}	2.29^{ab}	2.37^{a}	2.28^{ab}	0.17	*
28	2.21	2.23	2.30	2.33	2.29	0.21	NS
29	2.20^{b}	2.16^{b}	2.23^{b}	2.28^{ab}	2.41^{a}	0.16	*
30	2.07	2.06	2.14	2.23	2.38	0.29	NS
31	2.22^{b}	2.21^{b}	2.26^{b}	2.30^{b}	2.58^{a}	0.24	*
32	2.27	2.20	2.25	2.35	2.30	0.25	NS
33	2.31	2.21	2.22	2.57	2.40	0.37	NS
34	2.37	2.33	2.38	2.62	2.63	0.34	NS
35	2.33	2.31	2.38	2.57	2.55	0.34	NS
36	2.31	2.26	2.12	2.41	2.40	0.29	NS
37	2.39	2.37	2.12	2.33	2.53	0.25	NS
38	2.21	2.26	2.18	2.28	2.30	0.19	NS
39	2.20	2.46	2.23	2.36	2.39	0.19	NS
40	2.35	2.65	2.46	2.29	2.67	0.31	NS

*NS=not-significant (p>0.05); * p<0.05; ** p<0.01*

$^{a, b, c}$ Mean with different superscripts in the same row are significantly different.

SBM=Soybean meal; SHM=Shrimp head meal

Feed cost (BDT egg^{-1})

In most age groups of hens (19 to 26 and 30 to 36 weeks of age), the feed cost for egg production (BDT egg$^{-1)}$ did not differ substantially (p>0.05) as a result of SBM replacement of ration by SHM (**Table 9**). However, significantly the lowest feed cost per egg production was recorded in diet group at 100% replacement and highest feed cost was recorded in control group (no replacement) at 27-29 and 38 weeks of age indicating that feed cost decreased with SBM replacement of ration by SHM.

Mortality (%)

Table 10 displays the mortality rates of hens raised under various feed groups from 19 to 40 weeks. Data of the Table 10 showed that mortality (%) due to replacement of SHM with SBM was not different (p>0.05) with no mortality recorded in the control (no replacement) group during the experimental period. Mortality percentage of laying hens was found to be 3.51, 5.26, 1.67 and 3.33% in 25, 50, 75 and 100% replacement group respectively.

Table 9. Average feed cost (BDT egg^{-1}) for laying hens of different ages with varying substitution levels

Age of laying hens (week)	Rate of replacement of SBM by SHM (%)					LSD	Significance level
	0	25	50	75	100		
19	10.55	11.94	13.13	16.70	25.50	10.80	NS
20	5.48	5.30	6.68	6.86	9.36	3.15	NS
21	3.54	3.88	4.25	4.11	4.81	1.42	NS
22	3.31	3.19	3.20	3.11	3.46	0.40	NS
23	3.46	3.33	3.23	3.34	3.18	0.36	NS
24	3.62	3.42	3.25	3.46	3.23	0.34	NS
25	3.55	3.33	3.29	3.42	3.28	0.25	NS
26	3.65	3.41	3.41	3.47	3.31	0.30	NS
27	3.64^{a}	3.51^{ab}	3.48^{ab}	3.41^{b}	3.13^{c}	0.19	**
28	3.73^{a}	3.58^{a}	3.55^{a}	3.42^{ab}	3.19^{b}	0.30	*
29	3.73^{a}	3.48^{b}	3.45^{b}	3.38^{b}	3.36^{b}	0.20	*
30	3.49	3.32	3.32	3.31	3.33	0.40	NS
31	3.75	3.58	3.57	3.46	3.65	0.32	NS
32	3.80	3.53	3.52	3.48	3.32	0.39	NS
33	3.86	3.57	3.54	3.81	3.35	0.54	NS
34	3.99	3.72	3.77	3.89	3.75	0.48	NS
35	3.91	3.72	3.76	3.88	3.68	0.51	NS
36	3.89	3.65	3.39	3.63	3.46	0.43	NS
37	4.03^{a}	3.83^{ab}	3.35^{c}	3.48^{bc}	3.62^{bc}	0.39	*
38	3.79^{a}	3.71^{ab}	3.45^{bc}	3.52^{abc}	3.36^{c}	0.29	*
39	3.81^{ab}	3.09^{a}	3.57^{b}	3.68^{b}	3.58^{b}	0.34	*
40	4.10^{a}	4.41^{a}	3.96^{ab}	3.57^{b}	4.01^{ab}	0.45	*

*NS=not-significant (p>0.05); * p<0.05; ** p<0.01*
[a,b,c] Mean with different superscripts in the same row are significantly different. SBM=Soybean meal; SHM=Shrimp head meal.

Table 10. Mortality of laying hens between 19 and 40 weeks of age under different levels of substitution

SBM replacement rate by SHM (%)	Mortality (%) (Mean ± SE)
0% substitution of SBM by SHM	0.00±00
25% substitution of SBM by SHM	3.51±3.51
50% substitution of SBM by SHM	5.26±00
75% substitution of SBM by SHM	1.67±1.67
100% substitution of SBM by SHM	3.33±2.89
Overall mean	2.75±0.86
Level of significance	NS

NS=non-significant (p>0.05); SBM=Soybean meal; SHM=Shrimp head meal

Conclusion

The current study revealed that replacement of soybean meal with shrimp head meal had substantial effect on productive performance of laying hens. The highest egg production was observed in hens fed diets at 25% replacement of soybean meal with SHM. The highest egg weight was observed in the diet group at 25% replacement rate of SBM by SHM which was similar to that of control one. Replacement of 25% of SBM in chicken rations with SHM also improved feed utilization efficiency. Therefore, it can be concluded that chicken rations replaced with 25% SBM by SHM are suitable for good production of eggs, weight of eggs and feed efficiency.

Acknowledgement

The authors are grateful to the Ministry of Education, People's Republic of Bangladesh for financial support under the "Grants for Advanced Research in Science".

Conflict of Interest

The authors confirm that there is no conflict of interest with the publication of this article.

References

Adeyemi, O. A., Jimoh, B., & Olufade, O. O. (2013). Soybean meal replacement with cassava leaf: blood meal mix with or without enzyme in broiler diets. *Archivos de zootecnia*, *62*(238), 275-285. Retrieved from https://www.researchgate.net/publication/249991465_OA_Adeyemi_B_Jimoh_and_O_Olufade_Cassava_leaves_blood_meal_mix_as_replacement_for_soybean_meal_in_broiler_chicken_diets_with_or_without_enzyme_supplementation_Archivos_de_Zootechnia

Agunbiade, J. A., Tolorunji, B. O., & Awojobi, H. A. (2004). Shrimp waste meal supplementation of cassava products-based diet fed to broiler chickens. *Nigerian Journal of Animal Production*, *31*(2), 182-188. https://doi.org/10.51791/njap.v31i2.1796

Aktar, M., Rashid, M., Azam, M. G., Howlider, M. A. R., & Hoque, M. A. (2012). Shrimp waste and marine waste as substitutes of fish meal in broiler diet. *Bangladesh Journal of Animal Science*, *40*(1-2), 18-22. https://doi.org/10.3329/bjas.v40i1-2.10785

Ani, A. O., & Okorie, A. U. (2009). Performance of broiler finishers fed graded levels of processed castor oil bean (Ricinus communis L) meal supplemented with DL-methionine. *Nigerian Journal of Animal Production*, *36*(1), 61-73. Retrieved from https://www.researchgate.net/publication/24233795_Response_of_broiler_finishers_to_diets_containing_graded_levels_of_processed_castor_oil_bean_Ricinus_communis_L_meal

AOAC. (1990). Official Methods of Analysis. 15th Edition, Association of Official Analytical Chemist, Washington DC. Retrieved from https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://law.resource.org/pub/us/cfr/ibr/002/aoac.methods.1.1990.pdf&ved=2ahUKEwiTiIWJ87aFAxVm3jgGHU4_A8IQFnoECA8QAQ&usg=AOvVaw1QJxnIMH1Kx5uJoQaytu9P

Gernat, A. G. (2001). The effect of using different levels of shrimp meal in laying hen diets. *Poultry Science*, *80*(5), 633-636. https://doi.org/10.1093/ps/80.5.633

Hossain, M. I., Shikha, F. H., & Sharma, A. D. (2018). Waste management status of shrimp processing plants of south and south-west region of Bangladesh. *Journal of Environmental Science and Natural Resources*, *11*(1), 73-81. https://doi.org/10.3329/jesnr.v11i1-2.43374

Ijaiya, A. T., Alamede, I. C., & Erhnuanga, R. A. (2011). Replacement value of rubber seed (Hevea brasiliensis) meal for full-fat soya bean meal on performance, carcass characteristics and blood parameters of broilers. *Nigerian Journal of Animal Production*, *38*(2), 34-45. https://doi.org/10.51791/njap.v38i2.2790

Ingweye, J. N., Okon, B. I., Ubua, J. A., & Essien, A. I. (2008). Performance of broiler chickens fed fish and shrimp wastes. *Asian Journal of Animal Sciences*, 2(2), 58-63. https://doi.org/10.3923/ajas.2008.58.63

Islam, S. S., Paul, C., & Sarker, B. C. (2013). A comparative study on the performances of layer hybrids in some selected areas of Khulna region. *Bangladesh Journal of Animal Science*, *42* (2), 114-122. https://doi.org/10.3329/bjas.v42i2.18491

Oduguwa, O.O., Fanimo, A.O., Olayemi, V.O., & Oteri, N. (2004). The feeding value of sun-dried shrimp waste-meal based diets for starter and finisher broilers. *Archivos de Zootecnia,* 53(201), 87-90. Retrieved from https://www.redalyc.org/pdf/495/49520109.pdf

Okoye, F. C., Ojewola, G. S., & Njoku-Onu, K. (2005). Evaluation of shrimp waste meal as a probable animal protein source for broiler chicken. *International Journal of Poultry Science*, *4*(5), 458-461. https://doi.org/10.3923/ijps.2005.458.461

Rahman, M., & Koh, K. (2014). Nutritional quality and in vitro digestibility of shrimp meal made of heads and hulls of black tiger (Penaeus monodon), white leg (Litopenaeus vannamei) and argentine red (Pleoticus muelleri) Shrimps. *The Journal of Poultry Science*, *51*(4), 411-415. https://doi.org/10.2141/jpsa.0140002

Rahman, M., & Koh, K. (2016). Effect of shrimp meal made of heads of black tiger (Penaeus monodon) and white leg (*Litopenaeus vannamei*) shrimps on growth performance in broilers. *The Journal of Poultry Science*, *53*(2), 149-152. https://doi.org/10.2141/jpsa.0150008

Rosenfeld, D. J., Gernat, A. G., Marcano, J. D., Murillo, J. G., Lopez, G. H., & Flores, J. A. (1997). The effect of using different levels of shrimp meal in broiler diets. *Poultry science*, *76*(4), 581-587. https://doi.org/10.1093/ps/76.4.581

Samuel Olugbenga, O., Olusegun Abayomi, O., Adebimpe Oluseye, A., & Akinbowale Taiwo, T. (2015). Optimized nutrients diet formulation of broiler poultry rations in Nigeria using linear programming. *Journal of Nutrition & Food Sciences*, *14*(2). https://doi.org/10.4172/2155-9600.S14-002