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Preliminary study on the effect of feeding Black Soldier Fly Larvae (BSFL) on growth and laying performance of Japanese Quail (*Cortunix japonica*)

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Abstract Soybean meal and fish meal are common protein sources used in poultry feed, but both items need to be imported, causing higher feed costs in Malaysia. Black soldier fly larvae (BSFL) have been introduced and recommended for use as a protein source substitute and produced locally. The findings showed that in the treatment group with 25 percent BSFL, feed intake and FCR were significantly lower ($p<0.05$). In comparison, in the same treatment group, weight gain, average daily gain, egg weight, and the number of eggs was significantly higher ($p<0.05$). However, no significant effect was observed for the thickness of the shell of the egg. Since the thickness of the eggshell is similar to that of quails fed commercial diets, the BSFL dietary treatment still supported a satisfactory result on egg consistency. It is concluded that the ratio of 25 percent BSFL added to commercial feed is a leading ration, so that BSFL can be designated as an appropriate supplement feed for quail production.

Keywords: Black soldier fly larvae (BSFL), Japanese quail, Protein source, Poultry production, Poultry feed

Introduction

Quail is one of the poultry sources in Malaysia that provides protein with nutritional value and helps meet population demand and increase the level of self-sufficiency in the production of white meat. The Japanese quail (*Coturnix japonica*) is a commercial quail species domesticated for the production of eggs and meat, so the commercial species is generally divided into two lines, the egg line and the meat line. Growing the number of people in the world leads to a rise in the demand for food and animal output (Abdullah *et al.,* 2011).

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Therefore, farmers and producers need to look for an alternative way to increase production while reducing the cost of feed. In order to boost the performance of quails, the allocation of the source of protein in feed must be sufficient to ensure an improvement in the quail's weight gain during the growing process. Nevertheless, due to the expansion of feed costs due to the limited capital, which usually contributed from costly protein sources, there is a question about feedstuffs for poultry consumption (Iji *et al.*, 2017). The sources of protein commonly used in feedstuffs are soybean meal and fish meal. The amount of protein content is important since the development of the quail is key to raising it. Therefore, in order to address this issue, it is important to investigate the alternative source of protein supplemented in poultry feed with regard to reducing the cost and reliance on commercial feed.

As a good source of protein that could be used in feedstuffs, the Black Soldier Fly Larvae (BSFL) (*Hermatia Illucens*) was introduced and tested (Burtle *et al*., 2012). In addition, previous studies showed that BSFL contained a high percentage of crude protein, crude fat and metabolised energy (Table 1) and given an amino acid level comparable to that of fishmeal (Al-Qazzaz *et al*., 2016). According to Maurer *et al*. (2016), the findings do not indicate any issue in the efficiency of egg production by substituting the fish meal with the BSFL meal in feedstuffs for layer chicken. In addition, the change of the fish meal to BSFL meal in finisher broiler chicken feedstuffs showed better weight gain efficiency (Okah and Onwujiariri, 2012). Other than that, in a short time of about two to three days, BSFL could grow easily in organic waste (Widjastuti *et al.*, 2014). Figure 1 shows the lifecycle of the BSFL. In addition, BSFL is easy to cultivate and will not cause any damage or disease when eaten by farm animals. In addition, larvae bring many environmental and economic benefits, as they help improve farm sanitation and provide a good source of protein for livestock and agricultural animals. This research was therefore done to examine the effects of adding the BSFL meal to commercial poultry feed in order to increase the quails' efficiency and reduce the cost of feed.

Table 1. Composition of Black Soldier Fly Larvae (BSFL) (Al-Qazzaz *et al.*, 2016)

Component	Nutrient Composition
Dry matter (g/kg)	178±0.35
Crude protein (g/kg)	559.9±0.85
Crude fat (g/kg)	18.6±0.24
Ash (g/kg)	8.1±0.009
Ca (mg/g)	0.038±0.005
P (mg/g)	0.079±0.012
Metabolisable energy (kcal/kg)	696.3426±23.7

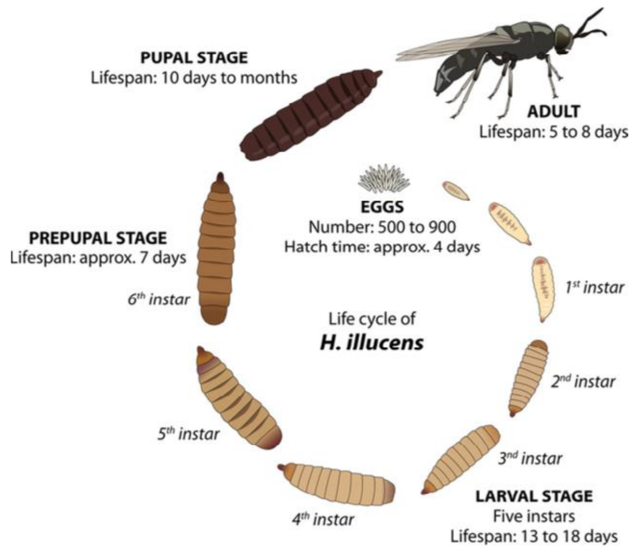

Figure 1. Lifecycle of black soldier fly (*H. illucens*) (De Smet *et al.*, 2018)

Materials and methods

Forty-eight of Japanese quails at the age of three weeks (21d) were raised until nine weeks aged. The bird was isolated in 12 cages and each cage consisted of four quails. The quails were provided with four different diet rations formulated which are; 25% BSFL, 20% BSFL, 15% BSFL and 0% BSFL as a control group, were added to the commercial feed. For each treatment, there were three replications of four animals each. Quails in control and all treatment groups were fed with starter feed ration during age three to four weeks. During five weeks of age, some of the quails started to lay eggs, thus they were provided with layer ration, while for the rest they were provided with layer ration when they have reached six weeks of age. The study protocol and procedure were approved by the Institutional Animal Care and Use Committee of Universiti Malaysia Kelantan (UMK/FIAT/ACUE/FYP/2/2018).

The BSFL had been dried by direct sunlight. The prepupae were put into the tray with the blocking shield around it. This shield helps to avoid the prepupae escaping from the sun upon their intrinsic photophobic nature and was set under direct sunlight for the drying process. This drying process was taking place until about 60% of moisture content in the prepupae reduce. During a rainy day, the drying process continues by putting them into the oven at 60 ℃, the right temperature is critical to avoid protein content denatured. Due to Tanford (1968), many factors may cause protein denatured including high temperature. Dry prepupae then grind into the powder form. There are four different formulated feed rations conducted in this study. For the production of meat and egg quail's diets required about 20-24% protein, 2,600 to 3,000 ME kcal/kg energy per kilogram, and 2.5%–3.0% calcium (Altine *et al*., 2016). Usually, the commercial feed nutritional provided about 19% crude protein and 3% of the calcium. The initial and remaining feed had been weight and recorded daily. The amount of feed supply is and clean water provided ad libitum.

The initial body weight of all quails was measured and recorded from the first day for every week. The calculation for the average daily gain (ADG) is as followed: -

$$\text{Average Daily Gain (g)} = \frac{\text{Finish weight} - \text{ start weight}}{\text{Age (d)}}$$

The feed intake and weight gain by the quail were recorded to measure the feed efficiency. In general, high efficiency in feed consumption represent as the animal consumes a small amount of the feed yet shows a significant increase in weight gain. Feed conversion ratio (FCR) formulation was used to measure feed efficiency. The formula for the FCR is as follows: -

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Average daily feed intake by the quail (g)}}{\text{Average daily gain (g)}}$$

All collected data was recorded according to the flock performance. The data of weight gain were recorded for every week while the feed intakes were recorded on a daily basis. The number and weight of eggs were recorded and measured when the quails started to lay eggs.

Statistical analysis

All data were analysed using One-Way Analysis of Variance (ANOVA) by IBM SPSS statistics version 23. The differences among means were identified using Duncan's multiple range tests. The level of significance was determined at $p<0.05$ for all analyses.

Results

Efficient characteristics, including feed intake, feed conversion ratio (FCR), weight gain, growth rate, egg weight and number of eggs, were significantly affected by dietary treatments with the addition of BFSL at a different stage. However, dietary treatments with BSFL may not have a noticeable effect on the shell thickness of the Japanese quail egg.

Growth performance

The findings showed that feed intake was reduced by rising the percentage of BSFL in the ration (Table 2). Significantly (P<0.05) the lowest feed intake was found in quails in treatment A; they were fed 25% of BSFL added to the diet. In this analysis, the results showed that commercial feed with supplementation of BSFL had a significant impact (P<0.05) on the feed conversion ratio (FCR) of quails, and the lowest FCR were identified in birds fed with ration supplemented with 25% of BSFL. Results also showed that supplementing BSFL in the quail diets had an important (p<0.05) impact on weight gain for body weight assessment. Greater weight gain from quails was observed in treatment with 25 percent BSFL, followed by treatment with 20 percent and 15 percent BSFL, and control with 161.1±3.87 g, 144.4±8.78 g, 135.4±21.54 g and 125.9±8.49 g, respectively as shown in Table 2.

Table 2. Effect of dietary treatments with different percentage of BSFL on growth performance of Japanese quails

Parameters	**Age**	**Treatments (mean ± standard deviation)**				***p*-value**
		25% BSFL	**20% BSFL**	**15% BSFL**	**0% BSFL**	
ADFI (g)	22-28d	3.1±0.38[a]	7.2±0.15[c]	6.2±0.35[b]	5.5±0.71[b]	0.050
	29-35d	4.1±0.45[a]	6.8±0.87[b]	5.1±0.44[ab]	7.3±0.51[c]	0.041
	36-42d	2.7±0.91[a]	6.8±0.38[c]	3.8±0.58[b]	6.4± 0.50[c]	0.035
	Overall	3.3±0.27[a]	6.9±0.7[b]	5.0±0.74[b]	6.5±0.14[b]	0.050
ADG (g)	22-28d	5.6±1.40[c]	4.0± 0.83[b]	1.8±0.29[a]	2.0±0.0[a]	0.036
	29-35d	3.3±0.59	2.6±0.15	3.0±0.38	1.9±0.22	0.121
	36-42d	2.0±0.37	1.6±0.10	2.0±0.07	1.4±0.49	0.460
	Overall	3.3± 0.19[b]	3.4±0.01[b]	2.8±0.10[a]	2.1±0.22[a]	0.050
FCR	22-28d	0.6±0.08[a]	1.8±0.41[b]	3.5±1.10[d]	2.8±1.00[c]	0.013
	29-35d	1.3±0.51[a]	2.7±1.04[c]	1.6±0.38[b]	3.9±1.62[d]	0.013
	36-42d	1.3±0.33[a]	4.2±1.24[b]	1.9±1.01[a]	4.6±0.45[b]	0.019
	Overall	1.0±0.76[a]	2.9±0.47[b]	2.4±0.98[b]	3.8±0.76[c]	0.020
WG (g)	22-28d	38.8±9.81[c]	28.0±5.86[b]	12.3±2.04[a]	13.8±0.29[a]	0.036
	29-35d	23.0±4.15	19.2±1.58	21.3±2.66	13.3±2.72	0.138
	36-42d	14.3±2.62	11.3±0.73	13.8±0.51	9.8±3.40	0.456
	Overall	30.6±1.34[c]	24.3±0.19[b]	19.5±0.73[a]	14.7±1.57[a]	0.05
BW (g)	21d	86±8.91	85±11.17	88±12.14	89±9.49	0.98
	22-28d	123.8±9.83[b]	114.0±8.49[a]	100.3±4.28[a]	102.8±7.66[a]	0.050
	29-35d	146.8±12.4[c]	133.2±8.72[b]	121.6±16.44[ab]	116.1±9.50[a]	0.014
	36-42d	161.1±3.87[c]	144.4±8.78[b]	135.4±21.54[ab]	125.9±8.49[a]	0.033

Laying Performance

Results for laying output indicated that supplementation of BSFL with 25%, 20% and 15% revealed a major ($p<0.05$) effect on quail egg mass as the recorded egg weight were 12.77 ± 0.38, 11.82 ± 0.22 and 11.26 ± 0.21, respectively (Table 3). In addition, as the average production was 66.00 ± 4.36 eggs, the 25 percent BSFL supplementation had a major effect on the number of eggs produced by the birds. Nevertheless, this study also found that BSFL had no meaning impact ($p>0.05$) on the shell thickness against the external consistency of the quail egg.

Table 3. Effect of dietary treatments with different percentage of BSFL on laying performance of Japanese quails

Parameters	**Treatments (mean ± standard deviation)**				***p*-value**
	25% BSFL	**20% BSFL**	**15% BSFL**	**0% BSFL**	
Egg weight (g)	12.8 ± 0.4[d]	11.8 ±0.2[c]	11.3 ±0.2[b]	10.6 ±0.1[a]	0.05
Shell thickness (μm)	0.2 ±0.1	0.3 ±0.3	0.22 ±0.0	0.2 ±0.1	0.31
Number of eggs	66.0 ± 4.4[c]	47.3 ±4.0[ab]	50.0 ±3.6[b]	41.0 ±1.0[a]	0.036

Discussion

Growth performance

The outcome of this research is in accordance with Widjastuti *et al.* (2014) as their results indicated that there was a higher percentage of BSFL in the reduction of feed intake in the diet. The same study noted that lower feed intake was better than a BSFL-containing diet due to the palatability of the commercial diet. The consumption of quail feed was affected by the energy level of their feed (Lotfi *et al.,* 2018). Increases in dietary BSFL lead to a higher content of protein and fat in the feed (Widjastuti *et al*., 2014). The higher supplemented fat or higher energy ration given will cause feed consumption to decrease and increase feed conversion or feed efficiency in laying hens (Zou and Wu, 2005). An indicator of the higher efficiency of feed utilisation was lower feed conversion ratio. It justified that the rised in BSFL percentage to 25 percent did not affect the palatability of the feed and the appetite of the quails. Up to 50 percent replacement of BFSL meal in the quail diets indicated that there had no detrimental effects on feed intake (Widjastuti *et al*., 2014).

Nevertheless, by using BSFL in the layer ration, the FCR was substantially (P<0.01) higher (Al-Qazzaz *et al*., 2016). Similar findings were reported by Amao *et al.* (2010) who stated that a considerably higher FCR in laying hens was caused by the substitution of fish meal with larval meal by 100 g/100 g. This may be due to the effect of chitin (Al-Qazzaz *et al.,* 2016), and about 9 percent of chitin is found in BSFL (Caligiani *et al.*, 2018) and according to Alagawany *et al.* (2014) Results showed that the body weight of the quails increased over 7 to 42 days of age as the protein given in the diet increased by 20 percent.

Laying performance

From the previous report, the findings of the laying efficiency are reviewed by replacing fish meal with maggot meal up to 50 percent showed that the egg size increased significantly (Widjastuti *et al*., 2014). The same result was also obtained for the development of eggs, because the total number of eggs did not have a major impact on the quail. Unlike Al-Daraji *et al*. (2010), this outcome was found to have a substantial effect (p<0.05) on the thickness of the quail eggshell and egg size as they given the linseed diet. Maurer *et al.* (2016) also strongly accepted that the rise or decrease in the consumption of maggot meal would not impact the overall production of eggs by quail as a result of the current research. It did not show major results, but it was discovered in this experiment that the quail continually produces eggs every day. The result showed that the nutrients supplied to the quail were adequated for the quail's egg production requirement. Vieira Filho *et al.* (2016) explained that quails with lower than 140 g body weight at 42 days of age showed a significance impact on poor productive results during the laying phase. Current research found that the external consistency of the quail egg had not influenced (p>0.05) on the shell thickness. Olgun *et al*. (2013) also found that there was no important impact of dietary intake on the shell thickness of the laying hens. Although, Pelicia *et al*. (2009) concluded differently, as they found that feed conversion ratio and eggshell consistency of poultry would be enhanced by gradually dieting calcium containing up to 4.5 percent. While there was no major impact on the thickness of the eggshell, the quail supplied with the BSFL in the diet ration never produced a poor eggshell quality as a result of the increase in the calcium content of the diet relative to the calcium content of commercial feed only. The research finding indicated that for better egg consistency, 2.5 percent to 3.5 percent calcium had provided to quail at later stage (Arpasova *et al.*, 2010). However, other variables contributed to the laying success of quails besides feed, including breed (Wahab *et al.*, 2018) lighting programme (Pizzolante *et al.*, 2006) and environmental effects (Redoy *et al.*, 2017).

The present results clearly show that supplementing the Black Soldier Fly Larvae with up to 25% of the ration in the quail diets improved growth and laying efficiency in Japanese quails except for the thickness of the shell of the egg. While there was no difference in the thickness of the shell, BSFL dietary treatment was still able to support an acceptable result on the consistency of the egg as the thickness of the shell of the egg is closed to that of the quails fed with commercial diets.

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