Iranian Journal of Veterinary Science and Technology

Received: 2022- Nov- 28
Accepted after revision: 2023- Aug- 30
Published online: 2023- Sep- 30

RESEARCH ARTICLE

DOI: 10.22067/ijvst.2023.79438.1204

Production performance of kampung hens fed rations containing black soldier fly larvae powder

Joice Jusmiaty Bana[a,b], Anggraini Barlian[a], Ahmad Ridwan[a]

[a] School of Life Sciences and Technology, Bandung Institute of Technology, Bandung-West Java, Indonesia.
[b] Department of Biology, Faculty of Sciences and Technics, University of Nusa Cendana, Kupang-West Timor, Indonesia.

ABSTRACT

This research aimed to find a suitable formulation for rations containing Black soldier fly larvae powder to support the optimal kampung hen production performance. Four to five-month-old Kampung hens were given feed with different amounts of black soldier fly larvae powder (n = 4 hens/treatment) to adjust protein and energy levels: R0 (commercial feed only, 17.53% protein, 3067 kcal/kg), R1 (14% protein, 2600 kcal/kg energy), R2 (14% protein, 2800 kcal/kg energy), R3 (16% protein, 2600 kcal/kg energy), R4 (16% protein, 2800 kcal/kg energy), R5 (18% protein, 2600 kcal/kg energy), R6 (18% protein, 2800 kcal/kg energy), R7 (20% protein, 2600 kcal/kg energy), R8 (20% protein, 2800 kcal/kg energy), R9 (22% protein, 2600 kcal/kg energy), and R10 (22% protein, 2800 kcal/kg energy). We measured several performance parameters, including body weight, feed consumption, specific growth rate, feed conversion ratio, visceral index, intraperitoneal fat index, and tissue protein content. Results show that treatment R6 produced significantly better overall performance ($p < 0.05$) than all other treatments except R5. Feed containing black soldier fly larvae powder with 18% protein content and 2800 kcal/kg energy is an inexpensive and readily available way to support the maximum growth of Kampung hens.

Keywords

Feed quality; Metabolic energy; Production performance; Livestock; Kampung hen; Poultry feed

Number of Figures: 5
Number of Tables: 5
Number of References:: 30
Number of Pages: 8

Abbreviations

BSF: black soldier fly
SGR: Specific Growth Rate
FCR: Feed Conversion Rate
VSI: Visceral index
IFI: Intraperitoneal Fat Index

Corresponding author: *Anggraini Barlian*
Email: aang@itb.ac.id
Tel: +62(81)2211-1483

Introduction

Good quality feed is a pivotal factor determining the success of livestock production and constitutes a significant portion of the costs in the livestock industry. In poultry farming, feed costs can account for 50-70% of the total operational cost [1]. Therefore, there is a need for cost-cutting methods that do not compromise on quality. Using high-quality feed has been demonstrated to enhance the productivity of Kampung chickens [2,3]. Good feed quality is determined by its ability to supply the animal's nutritional requirements (i.e., protein, carbohydrates, fat, vitamins, and minerals). The quality of the feed is also determined by its composition and balance of nutrients [4]. Moreover, good quality feed must be available year-round to maintain optimal performance and production. Sustainable feed provision is reliant on the availability of raw materials.. Specifically, the raw materials of feed must be easy to obtain, relatively cheap, not compete with human needs, and have a high nutrient content. Feed quality is directly related to feed efficiency. Optimization of feed efficiency is dependent on the formulation of balanced rations, especially concerning protein and energy. The right balance between protein and energy in a ratio increases the efficiency of feed use by the animal, thereby reducing overall production costs [5].

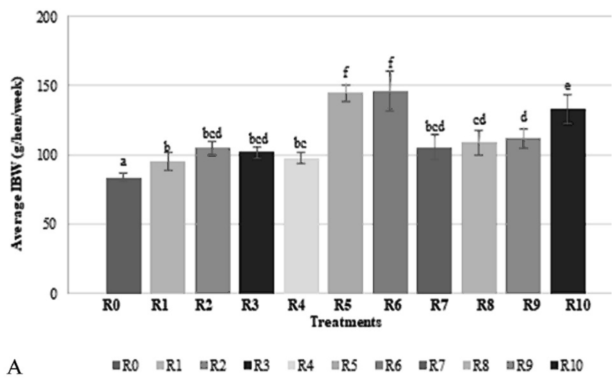
Alternative raw materials for poultry feed that are cheap and readily available include components of agricultural or insect waste. According to van Huis [6], using insect proteins in feed is cost-effective and eco-friendly. Insects can quickly and easily be mass-produced and have a high feed conversion efficiency. Cultivation of insects could reduce the amount of organic waste that potentially pollutes the environment [7]. Furthermore, Veldkamp et al. [8] also reported that using insects as a protein source for feed was beneficial because it does not compete with human needs. One insect that has been widely studied as a protein source in feed is the black soldier fly (BSF) due to its high protein (40–50%) and fat (29–32%) content [9]. BSF larvae powder is a suitable alternative feed additive for broiler chickens [10–12], Jian carp fish [13], and quail [14–16].

Kampung chicken has low productivity but has high economic value, especially eggs and meat. The demand for kampung chicken meat and eggs in Indonesia has increased yearly. Fitri [17] reports that the consumption of Kampung chicken meat in 2015 was only 314 thousand tons (16%) of the total meat production of 3.06 million tons, and in 2016 increased to 26%. It is further stated that this demand will continue to increase in line with population growth and awareness of the importance of organic food products. Efforts are needed to increase the productivity of Kampung chickens to meet this increasing demand. One way to increase the productivity of Kampung chickens is to provide quality feed according to the age of the chickens. Charlton et al. [18] analyzed the security of some insects as a source of protein in feed livestock, such as house flies (Musca domestica), Bluebottle flies (Calliphora vomitoria), blowflies (Chrysomyaspp), and BSF. Therefore, the present study evaluated the effects of feed containing BSF larvae powder as a protein source on the production performance of Kampung hen.

Result

Effect of treatment on body weight

Table 1 and Figure 1a illustrate that the greatest change in body weight was obtained with R6, whereas treatment R0 elicited the smallest change. The change in body weight obtained with R6 was significantly different from all other treatments except R5.



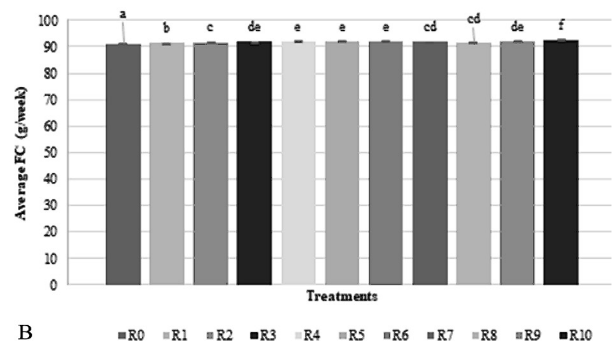


Figure 1.
A. Average increase in body weight (IBW; g/hen/week) during an eight-week observation period. **B.** Average feed consumption (FC; g/week) during an eight-week observation period. Different letters (a,b,c,d,e,f) indicate significant differences ($p < 0.05$).

Table 1.
Amino acid analysis of the experimental feed

Feed	R0 (%)	R1 (%)	R2 (%)	R3 (%)	R4 (%)	R5 (%)	R6 (%)	R7 (%)	R8 (%)	R9 (%)	R10 (%)
Aspartic acid	1.00	1.01	1.03	1.15	1.26	1.29	1.38	1.49	1.58	1.68	1.88
Glutamic acid	1.68	1.74	2.54	2.61	2.76	2.89	3.33	3.46	3.37	3.43	3.78
Serine	0.43	0.48	0.48	0.57	0.64	0.72	0.87	0.89	0.89	0.93	1.00
Glycine	0.77	0.81	0.83	0.88	0.94	1.13	1.24	1.21	1.26	1.29	1.32
Histidine	0.54	0.60	0.63	0.70	0.78	0.81	0.79	0.77	0.82	0.90	0.91
Arginine	0.67	0.66	0.70	0.69	0.72	0.79	0.75	0.70	0.78	0.82	0.88
Threonine	0.53	0.59	0.68	0.71	0.66	0.75	0.82	0.81	0.83	0.85	0.92
Alanine	0.41	0.48	0.52	0.57	0.54	0.69	0.76	0.75	0.78	0.80	0.83
Proline	0.84	0.90	0.92	0.95	1.12	1.20	1.15	1.18	1.20	1.21	1.37
Tyrosine	0.74	0.79	0.78	0.83	0.90	0.88	0.91	0.93	1.00	1.05	1.15
Valine	0.66	0.70	0.90	0.86	0.80	0.77	0.73	0.69	0.80	0.82	0.87
Methionine	0.50	0.47	0.52	0.60	0.65	0.70	0.71	0.67	0.72	0.76	0.81
Cystein	0.31	0.37	0.42	0.52	0.50	0.54	0.59	0.60	0.63	0.68	0.71
Isoleucine	0.67	0.70	0.73	0.80	0.82	0.76	0.79	0.80	0.80	0.83	0.88
Leucine	1.01	1.17	1.22	1.30	1.30	1.29	1.30	1.36	1.32	1.38	1.51
Phenylalanine	0.52	0.57	0.56	0.67	0.70	0.67	0.69	0.72	0.75	0.77	0.88
Lysine	0.75	0.82	0.79	0.84	1.00	1.04	1.13	1.18	1.25	1.29	1.34

Analysis was performed by the Feed Science and Technology Laboratory, IPB-Faculty of Animal Husbandry, Department of Nutrition Science and Feed Technology, Division of Feed Technology and Industry.

Effect of treatment on feed consumption

The results showed that the different feed treatments had a significant effect on the consumption of feed ($p < 0.05$). In particular, the consumption of feed R6 was significantly higher than all others, while the consumption of R0 was significantly lower. Importantly, heightened consumption of R10 was not followed by a high growth rate (Table 1 and Figure 1b). Results of Amino acid analysis revealed that all the experimental feeds contained essential and nonessential amino acids, albeit at different concentrations (Table 2).

Effect of treatment on SGR (Specific Growth Rate)

As with changes in body weight, the SGR of chickens treated with feed R6 was significantly higher ($p < 0.05$) than all other feeds except R5 (Table 1 and Figure 2a).

Effect of treatment on FCR (Feed Conversion Rate)

The results showed the feed treatments had significant effects on the FCR ($p < 0.05$; Table 1 and Figure 2b). Body weight Changes and SGR values are

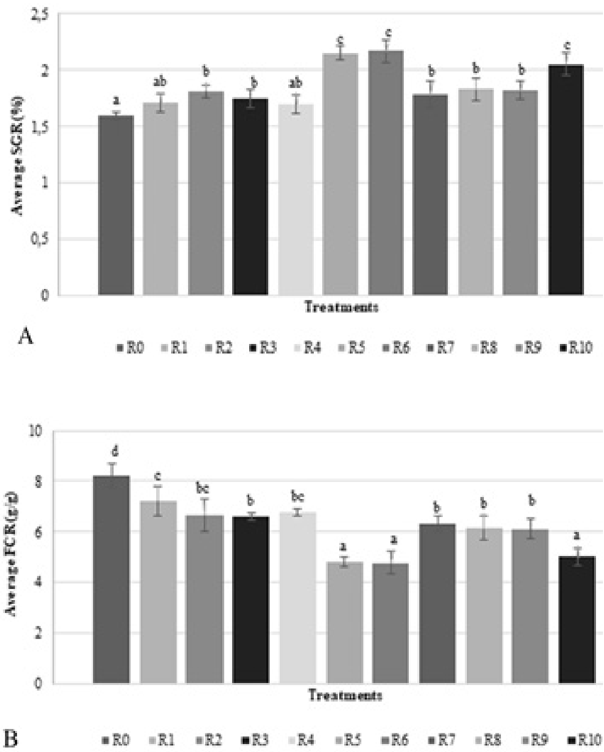


Figure 2.
A. Average SGR (%) during an eight-week observation period. **B.** Average feed conversion ratio (FCR; g/g)) during an eight-week observation period. Different letters (a, b, c, d) indicate significant differences ($p < 0.05$).

determined by the FCR, not feed consumption, as shown by the current results (Table 3).

Effect of treatments on VSI (Visceral index)

The VSI obtained with treatment R6 was significantly higher ($p < 0.05$) than that with all others except R5 (Table 3 and Figure 3). This high VSI was due to the high body weight achieved by the end of the experimental period. While feed R0 had the lowest VSI, it was not significantly different ($p > 0.05$) with R2, R3, or R7–R10.

Effect of treatments on IFI (Intraperitoneal Fat Index)

The IFI for treatment R10 was significantly higher than all other feeds ($p < 0.05$; Table 3 and Figure 4). The high IFI R10 indicated that a feed with 22% protein and 2800 kcal/kg energy had excess nutrition for chickens during the growth phase, which was converted into intraperitoneal fat. R10 also had the highest feed consumption (Table 4), further contributing to the high IFI. This result was supported by the lower tissue protein content obtained with treatment R10 (Table 3).

Table 2.
Increase in body weight (IBW), feed consumption (FC), specific growth rate (SGR), and feed conversion rate (FCR) during an eight-week-observation period

Treatments	IBW (g/ week)	FC (g/week)	SGR (%)	FCR (g/g)
R0	83.87 ± 3.27^{a}	90.96 ± 0.31^{a}	1.59 ± 0.04^{a}	8.23 ± 0.47^{d}
R1	95.44 ± 5.30^{b}	91.32 ± 0.06^{b}	1.71 ± 0.08^{ab}	7.22 ± 0.57^{c}
R2	105.09 ± 4.93^{bcd}	91.62 ± 0.09^{c}	1.81 ± 0.06^{b}	6.66 ± 0.63^{bc}
R3	102.13 ± 3.94^{bcd}	91.85 ± 0.05^{de}	1.74 ± 0.08^{b}	6.58 ± 0.14b
R4	97.81 ± 3.82^{bc}	92.07 ± 0.12^{e}	1.70 ± 0.08^{ab}	6.75 ± 0.13^{bc}
R5	144.25 ± 6.03^{f}	91.89 ± 0.14^{de}	2.15 ± 0.06^{c}	4.83 ± 0.19^{a}
R6	145.81 ± 14.29^{f}	91.90 ± 0.09^{de}	2.17 ± 0.10^{c}	4.77 ± 0.46^{a}
R7	105.75 ± 8.71^{bcd}	91.75 ± 0.08^{cd}	1.78 ± 0.12^{b}	6.32 ± 0.34^{bc}
R8	108.81 ± 8.64^{cd}	91.69 ± 0.20^{cd}	1.84 ± 0.10^{b}	6.14 ± 0.46^{bc}
R9	111.84 ± 7.07^{d}	91.92 ± 0.05^{de}	1.83 ± 0.08^{b}	6.10 ± 0.39^{b}
R10	133.31 ± 10.15^{e}	92.42 ± 0.05^{f}	2.05 ± 0.10^{c}	5.02 ± 0.33^{a}

Data in a column with different superscripts (a, b, c, d, e, f) differ significantly ($p < 0.05$).

Effect of treatments on tissue protein content

The tissue protein content obtained with feed R5 was significantly higher ($p < 0.05$) than all others except R6, while R1 produced the lowest (Table 3 and Figure 5).

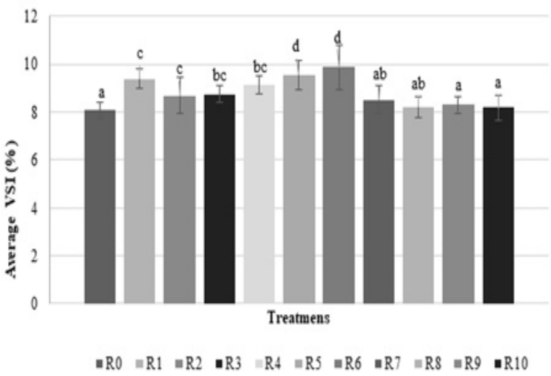


Figure 3.
Average visceral index (VSI; %) during an eight-week observation period. Different letters (a, b, c, d) indicate significant differences ($p < 0.05$).

Table 3.
Visceral Index (VSI), Intraperitoneal Fat Index (IFI), and tissue protein content of each treatment

Treatments	VSI (%)	IFI (%)	Tissue Protein Content (%)
R0	8.07 ± 0.33^{a}	1.11 ± 0.05^{a}	21.48 ± 0.77^{e}
R1	9.39 ± 0.42^{cde}	1.77 ± 0.08^{c}	17.83 ± 0.16^{a}
R2	8.69 ± 0.78^{abcd}	1.43 ± 0.04^{b}	19.49 ± 0.15^{bc}
R3	8.75 ± 0.35^{abcd}	1.66 ± 0.03^{c}	21.21 ± 0.86^{e}
R4	9.15 ± 0.37^{bcd}	1.73 ± 0.02^{c}	18.78 ± 0.16^{ab}
R5	9.55 ± 0.639^{de}	1.34 ± 0.03^{b}	26.36 ± 0.21^{g}
R6	9.87 ± 0.94^{e}	1.39 ± 0.11^{b}	25.296 ± 0.50^{g}
R7	8.51 ± 0.59^{abc}	1.68 ± 0.04^{c}	20.66 ± 0.13^{de}
R8	8.21 ± 0.44^{a}	1.88 ± 0.10^{d}	24.39 ± 0.34^{f}
R9	8.30 ± 0.37^{ab}	1.91 ± 0.10^{d}	19.85 ± 0.42^{cd}
R10	8.18 ± 0.51^{a}	2.11 ± 0.09^{e}	19.79 ± 0.27^{bcd}

Different superscript (a, b, c, d, e, f, g) in the same column indicates data significantly different ($p < 0.05$).

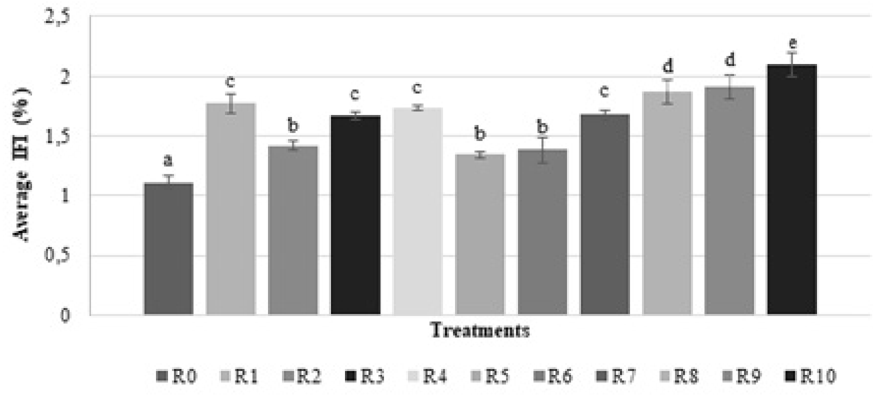


Figure 4.
Average intraperitoneal fat index (IFI, %) during an eight-week observation period. Different letters (a, b, c, d, e) indicate significant differences ($p < 0.05$).

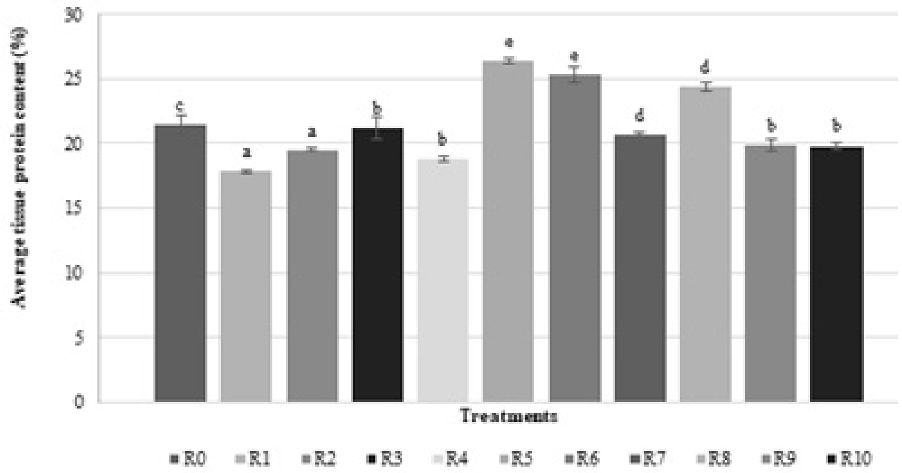


Figure 5.
Average tissue protein content (%) during an eight-week observation period. Different letters (a, b, c, d, e) indicate significant differences ($p < 0.05$).

Discussion

Effect of treatment on body weight

These results are similar to a study by Abun et al. [19], who found that Kampung chickens fed 2750 kcal/kg energy and 17% protein had the best production performance. Similarly, Sidadolog and Yuwanta [4] found the greatest change in body weight for Marawang chicks was with feed containing 18% crude protein and 2690 kcal/kg energy.

The high increase in body weight with R6 corresponded to a low feed conversion ratio and high SGR. The lack of significant difference in body weight change between R5 and R6 indicates that feeds containing the same protein level likely result in similar changes in body weight, assuming the energy content is also balanced. However, diets with higher protein and metabolic energy levels did not necessarily equate to heavier body weight. This result indicates that optimum growth is obtained only with the right balance between protein and energy corresponding to the physiological condition of the animal, meaning the animal was able to maximize the conversion of consumed feed into biomass [20]. This is in agreement with Tortora and Grabowski in Abun et al. [19], who stated that the balance between the ratio of protein and energy and the presence of other nutrients in the feed plays an important role in maximizing body weight gains.

Protein quality is determined by the amino acid composition, especially the essential amino acids. Hence, the more complete and appropriate the amount of essential amino acids, the better the protein quality of the feed. In particular, methionine and lysine are the amino acids most needed for chicken growth; the reported maximal requirements of methionine and lysine in poultry diets are 0.38-0.42% and 0.8-1.0%, respectively [5]. Though experimental feed R6 contained 0.71% methionine and 1.13% lysine, other feeds contained higher levels. This suggests that higher concentrations of amino acids in the feed do not guarantee greater changes in body weight.

Effect of treatment on feed consumption

Increased consumption of R10 did not result in a high growth rate. This was likely due to its high FCR compared to R6. Such a high FCR indicates the limited ability to convert consumed feed into biomass and suggests protein and energy levels may be greater than the needs of the animal, with the excess being excreted as waste [5]. On the other hand, while consumption of feeds R3, R5, R6, and R9 was not significantly different, these feeds did result in different body weight changes. This indicates that body weight change did not directly correlate with feed consumption. Sidadolog and Yuwanta [4] stated that body weight correlates with feed conversion rate, not feed consumption.

Effect of treatment on SGR (Specific Growth Rate)

SGR values were inversely correlated with the feed conversion ratio, where the lower the feed conversion ratio, the higher the SGR. Importantly, higher protein and energy levels did not guarantee a high SGR, indicating that optimum growth was reached only when rations contained protein and energy levels appropriate for the physiological conditions of the animal. This result was in agreement with the results of Abun et al. [19], who stated that an appropriate balance between protein and energy in the feed has a positive effect on growth.

Effect of treatment on FCR (Feed Conversion Rate)

The FCR represents the ability of the animal to convert consumed feed into biomass; a low FCR indicates a higher ability to convert the consumed ration into biomass and vice versa. Feed R6 had a significantly lower FCR than all others except R5, and the highest was obtained with R0. An FCR of 4.77 (R6) indicates that chickens consuming feed with 18% protein and 2800 kcal/kg energy needed to consume 4.77 kg feed to increase their body weight by 1 kg. The absence of significant difference between treatments R5 and R6 implies both produced the same change in body weight. This result is similar to that of Iskandar et al. who obtained an FCR of 4.79 for Kampung chickens fed a ratio of 17% protein [21]. On the other hand, Mahardika et al. [5] obtained an FCR of 9.39 by feeding 10- to 20-week-old Kampung chickens containing 18% protein and 2900 kcal/kg metabolic energy , which was also in accordance with a report by Sidadolog and Yuwanta [4].

Effect of treatments on IFI (Intraperitoneal Fat Index)

These present results were higher than the resultsobtained by Iskandar et al. [21], who reported an abdominal fat index of 0.82% for Kampung hen. This difference could be due to genetic differences in chicken strains that are related to protein and metabolic energy level differences.

Effect of treatments on tissue protein content

The high tissue protein content with feeds R5 and R6 corresponded to their low feed conversion ratio and high increase in body weight. This indicates that a feed with 18% protein and 2800 kcal/kg contained the required nutrition, especially protein, that was optimal for Kampung hens during their growth phase. This result was similar to that reported by Abun et al. [19], who stated that high protein quality affects muscle protein.

Conclusions

The results of the present study showed that feed containing BSF larvae powder at 18% protein and 2800 kcal/kg energy (R6) contains balanced, adequate nutrition to support the optimal growth of Kampung hens. Based on the findings of this research, using feed with 18% crude protein and 2800 kcal/kg of metabolic energy results in the optimal growth of kampung hens.

Materials and Methods

Time and place of research

This research was conducted in Kupang, East Nusa Tenggara, from July to November 2018.

Animal treatment

A total of 44 Kampung hens (Gallus gallus domesticus) aged 4 to 5 months old were used. All Kampung hens were reared in-house and individually placed in 50 × 50 × 70 cm cages containing bowls for feed and water. The Kampung hens received feed containing different BSF larvae powder treatments (n = 4 hens/treatment). Hens initially received 70 g of feed, and subsequent amounts of feed added were adjusted based on the remaining amounts of feed. Water was given ad libitum.

Experimental feed

The raw materials present within the feed included BSF larvae powder, cornmeal, soybean meal, tapioca flour, fish flour, rice bran, and premix. Premix Composition (in 10 kg): Calcium 4.500 g, Sodium 800 g, Mangan 33 g, Phosphor 3.500 g, Magnesium 297 g, Ferrum 44 g, Zincum 33 g, Cholin 750 g, Cobalt 100 mg, Cuprum 5.500 mg, Iodine 550 mg, Vitamin B1 1.500 mg, Vitamin A 7.500.00 I.U dan Vitamin D3 1.500.000 I.U. Each ingredient was analyzed for its crude protein content and metabolizable energy (Bomb Calory Meter) [22,23], as a basis for formulating the feed. The dried BSF larvae, cornmeal, soybean meal, and fish purchased from the marketplace are blended into flour without reducing fat for BSF. BSF larvae and fish meal as a source of animal protein; soybean meal as a source of vegetable protein; Cornflour, rice bran, and tapioca as a source of carbohydrates, and Premix as a source of vitamins and minerals.

Experimental feed treatments included different amounts of BSF larvae powder (R1–R10) to adjust protein and energy levels as follows: R0 (commercial feed without BSF larvae powder, 17.53%

protein, 3067 kcal/kg energy), R1 (14% protein, 2600 kcal/kg energy), R2 (14% protein, 2800 kcal/kg energy), R3 (16% protein, 2600 kcal/kg energy), R4 (16% protein, 2800 kcal/kg energy), R5 (18% protein, 2600 kcal/kg energy), R6 (18% protein, 2800 kcal/kg energy), R7 (20% protein, 2600 kcal/kg energy), R8 (20% protein, 2800 kcal/kg energy), R9 (22% protein, 2600 kcal/kg energy), and R10 (22% protein, 2800 kcal/kg energy). Proximate and amino acid analyses were performed on the formulated feed with the desired protein and energy levels. Feed composition, proximate analysis, and amino acid analysis results are shown in Tables 4, 5, and 1, respectively. The duration of the experimental feeding period was a total of 8 weeks.

Table 4.
Composition of feed

Raw material (kg)	ME 2600 kcal/kg					ME 2800 kcal/kg				
	14%	16%	18%	20%	22%	14%	16%	18%	20%	22%
BSF powder	9	12	15	18	21	9	12	15	18	21
Corn flour	31.67	26.63	21.59	16.55	11.51	45.59	40.55	35.51	30.47	25.43
Soy flour	5	5	5	5	5	5	5	5	5	5
Tapioca flour	5	5	5	5	5	5	5	5	5	5
Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fish flour	0.34	2.79	5.23	7.67	10.12	2.17	4.62	7.06	9.50	11.95
Rice bran	48.49	48.09	47.68	47.28	46.87	32.74	32.34	31.93	31.53	31.12
Total	100	100	100	100	100	100	100	100	100	100
ME, kcal/kg	2600	2600	2600	2600	2600	2800	2800	2800	2800	2800
PC, %	14.0	16.0	18.0	20.0	22.0	14.0	16.0	18.0	20.0	22.0

ME = metabolizable energy; PC = crude protein

Table 5.
Proximate composition analysis of the experimental feed

Feed	% DM	% Ash	% OM	% CP	% CL	% CF
R0	89.94	4.07	85.87	16.762	6.44	5.06
R1	89.72	7.58	82.14	13.840	4.84	14.16
R2	88.98	6.09	82.89	14.127	4.91	12.59
R3	89.31	7.35	81.96	15.645	4.63	12.57
R4	88.78	6.58	82.20	15.825	5.03	12.27
R5	90.02	8.67	81.35	17.951	8.43	14.90
R6	88.78	6.44	82.34	17.742	7.44	10.60
R7	89.48	8.04	81.44	20.375	8.28	14.03
R8	89.14	7.59	81.55	19.861	8.17	11.40
R9	89.41	9.26	80.15	22.401	8.22	13.63
R10	89.01	7.90	81.10	22.670	8.87	10.59

Analysis was performed at the Nutrition and Livestock Feed Laboratory, Agriculture Polytechnic, Nusa Cendana University, Kupang. DM: dry matter, Ash, OM: organic matter, CP: Crude protein, CL: Crude Lipid, CF: Crude fiber.

Authors' Contributions

J.J.B., A.B., and A.R.conceived and planned the experiments. J.J.B., A.B., and A.R. carried out the experiments. J.J.B. and A.B. contributed to sample preparation. A.B., A.B. contributed to the interpretation of the results. J.J.B. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Acknowledgements

Not applicable

Competing Interests

The authors declare that there is no conflict of interest.

Reference

1. Katayane FA, Bagau B, Wolayan FR, Imbar MR. Produksi dan Kandungan Protein Maggot (Hermetia illucens) den- gan menggunakan Media Tumbuh Berbeda [Production and Protein Content of Maggot (Hermetia illucens) using Different Growing Media]. Zootec. 2014 Jun 4;34:27. Doi:10.35792/zot.34.0.2014.4791

2. Sinurat A, Santoso JE, Sumanto MT, Wibowo B. Peningkatan Produktivitas Ayam Buras melalui Pendekatan Sistem Usaha Tani pada Peternak Kecil [Increasing Domestic Chicken Productivity through Farming System Approach for Small Farmers]. Ilmu dan Peternakan. 1992;5:73–7.

3. Sumanto EJ, Iskandar S, Wibowo B, Santoso R, Rusmana N. Pengaruh Perbaikan Tatalaksana terhadap Penampilan Usaha Ternak Ayam Buras di Desa Pangradin: Suatu Analisa Ekonomi [The Effect of Management Improvements on the Performance of Freerange Chicken Farming in Pangradin Village: An Economic Analysis]. Ilmu dan Peternakan. 1990;4:322–8.

4. Sidadolog JHP, Yuwanta T. Effect of Protein-Energy Concentration in Feed on Body Weight Gain, Energy and Protein Efficiency in the Growth Period of Merawang Chicken. Animal Production. 2009;11(1):15–22.

5. Mahardika IG, Kristina Dewi GAM, Sumadi IK, Suasta IM. Kebutuhan Energi dan Protein untuk Hidup Pokok dan Pertumbuhan pada Ayam Kampung Umur 10-20 Minggu [Energy and Protein Needs for Basic Life and Growth in Kampung Chickens Age 10-20 Weeks]. Majalah Ilmiah Peternakan. 2013;16:6–11.

6. van Huis A. Potential of Insects as Food and Feed in Assur- ing Food Security. Annual Review of Entomology. 2013 Jan 7;58(1):563–83. https://doi.org/10.1146/annurev-ento-120811-153704

7. Li Q, Zheng L, Qiu N, Cai H, Tomberlin JK, Yu Z. Bioconversion of Dairy Manure by Black Soldier Fly (Diptera: Stratiomyidae) for Biodiesel and Sugar Production. Waste Management. 2011 Jun;31(6):1316–20. Doi:10.1016/j.wasman.2011.01.005

8. Veldkamp T, Van Duinkerken G, van Huis A, Lakemond CMM, Ottevanger E, Bosch G, Van Boekel T. Insects as a Sustainable Feed Ingredient in Pig and Poultry Diets: A Feasibility Study. Netherlands: Wageningen UR Livestock Research. 2012; 1–10.

9. Bosch G, Zhang S, Oonincx DGAB, Hendriks WH. Protein Quality of Insects as Potential Ingredients for Dog and Cat Foods. Journal of Nutritional Science. 2014;3:1–4. Doi:10.1017/jns.2014.23

10. Dahiru SJ, Azhar BK, Anjas BS. Performance of Spring Chicken Fed Different Inclusion Levels of Black Soldier Fly Larvae Meal. Entomology, Ornithology & Herpetology: Current Research. 2016 Jan 1;5:1–4.

11. Rambet V, Umboh JF, Tulung YLR, Kowel YHS. Kecernaan Protein dan Energi Ransum Broiler Yang Menggunakan Tepung Maggot (Hermetia illucens) sebagai Pengganti Tepung Ikan [Kecernaan Protein dan Energi Ransum Broiler Yang Menggunakan Tepung Maggot (Hermetia illucens) sebagai Pengganti Tepung Ikan]. Zootec. 2016;35(2):13–22. Doi:10.35792/zot.36.1.2016.9314

12. Schiavone A, Cullere M, De Marco M, Meneguz M, Biasato I, Bergagna S, Dezzutto D, Gai F, Dabbou S, Gasco L, Dalle Zotte A. Partial or Total Replacement of Soybean Oil by Black Soldier Fly Larvae (Hermetia illucens L.) Fat in Broiler Diets: Effect on Growth Performances, Feed-Choice, Blood Traits, Carcass Characteristics and Meat Quality. Italian Journal of Animal Science. 2016;16(1):93–100. Doi:10.1080/1828051X.2016.1249968

13. Li S, Ji H, Zhang B, Tian J, Zhou J, Yu H. Influence of Black Soldier Fly (Hermetia illucens) Larvae Oil on Growth Performance, Body Composition, Tissue Fatty Acid Composition and Lipid Deposition in Juvenile Jian Carp (Cyprinus carpio var. Jian). Aquaculture. 2016 Dec;465:43–52. Doi:10.1016/j.aquaculture.2016.08.020

14. Cullere M, Tasoniero G, Giaccone V, Miotti-Scapin R, Claeys E, De Smet S, Dalle Zotte A. Black Soldier Fly as Dietary Pro- tein Source for Broiler Quails: Apparent Digestibility, Excreta Microbial Load, Feed Choice, Performance, Carcass and Meat Traits. Animal. 2016;10(12):1923–30. Doi:10.1017/S1751731116001270

15. Harlystiarini H. Tepung Larva Black Soldier Fly (Hermetia illucens) sebagai Sumber Protein Alternatif Pengganti Tepung Ikan pada Puyuh Petelur Yang Mati (Cortunix cortunix japonica) [Black Soldier Fly (Hermetia illucens) Larva Flour as an Alternative Protein Source to Replace Fish Meal on Dead Laying Quail (Cortunix cortunix japonica)] [Master thesis]. [Bogor]: Bogor Institute of Agriculture; 2017.

16. Newton L, Sheppard C, Watson DW, Burtle G, Dove CR. Us-

ing the Black Soldier Fly, Hermetia illucens, as a Value-Added Tool for the Management of Swine Manure: Report of the Animal and Poultry Waste Management Center. Raleigh, NC: North Carolina State University.2005.

17. Fitri S. Konsumsi Ayam Kampung Lokal Digenjot [Consumption of Local Village Chicken is Boosted] [Internet]. Republika Online. 2016 [cited 2020 Oct 12].

18. Charlton A j., Dickinson M, Wakefield M e., Fitches E, Kenis M, Han R, Zhu F, Kone N, Grant M, Devic E, Bruggeman G, Prior R, Smith R. Exploring the Chemical Safety of Fly Larvae as a Source of Protein for Animal Feed. Journal of Insects as Food and Feed. 2015;1(1):7–16. Doi:10.3920/JIFF2014.0020

19. Abun A, Darana S, Tanwiriah W, Indrijani H, Asmara IY, Taslim T. Influence of Different Energy-Proteins on Performance and Blood Hematological on Three Types of Local Chicken. International Journal of Environment, Agriculture and Biotechnology. 2018;3(5):1816–24. Doi:10.22161/ijeab/3.5.33

20. Widodo E. Teori dan Aplikasi Pembuatan Pakan Ternak Ayam dan Itik [Theory and Application of Making Chicken and Duck Feed]. Jurnal Peternakan. 2010;1:1–14.

21. Iskandar S, Z D, Sastrodihardi S, Sartika T, Setiadi P, Susanti T. Growth Response of Kampung and Pelung Cross Chickens to Diet Differed in Protein Content. Jurnal Ilmu Ternak dan Veteriner. 1998;3(1):8–14.

22. PanReacAplliChem. Nitrogen determination by Kjeldahl method. Barcelona: ITW Reagents; 2018.

23. Linde KO. Measuring calories in food: The bomb calorimeter. New Hampshire, USA: Fisher Scientific. 2007.

24. Efendi H. Study water quality for management and resources the aquatic environment. Yogyakarta: Kanisius. 2003.

25. Takeuchi T. Laboratory work-chemical evaluation of dietary nutrients. In: Watanabe, editor. Fish nutrition and mariculture. Tokyo: Tokyo University Press. 1998.

26. Lestari, R, Darmawan, A, Wijayanti, I. Suplementasi Mineral Cu dan Zn dalam Pakan terhadap Organ Dalam [Supplementation of Cu and Zn Minerals in Feed for Internal Organs]. Jurnal Ilmu Nutrisi dan Teknologi Pakan (Nutrition and Feed Technology Journal). 2020;18(3):74–80. Doi:10.29244/jintp.18.3.74-80

27. Irwani N, Candra A A. Aplikasi Ekstrak Daun Binahong (Anredera cordifilia) terhadap Kondisi Fisiologis Saluran Pencernaan dan Organ Viceral pada Broiler [Application of Binahong Leaf Extract (Anredera cordifilia) on Physiological Conditions of the Digestive Tract and Viceral Organs in Broilers]. PETERPAN (Jurnal Peternakan Terapan). 2020;2(1):22–29. Doi:10.25181/peterpan.v2i1.1716

28. Fouad A M. El-Senousey H K. Nutritional factors affecting abdominal fat deposition in poultry: A review. Asian-Australasian Journal of Animal Sciences. 2014;27(7):1057–1068. Doi:10.5713/ajas.2013.13702

29. Chen CY, Huang YF, Ko YJ, Liu YJ, Chen YH, Walzem RL, Chen SE. Obesity-associated cardiac pathogenesis in broiler breeder hens: development of metabolic cardiomyopathy. Poultry Science. 2017;96:2438-2446. Doi:10.3382/ps/pex016

30. Chen CY, Lin HY, Chen YW, Ko YJ, Liu YJ, Chen YH, Walzem RL, Chen SE. Obesity-associated cardiac pathogenesis in broiler breeder hens: pathological adaption of cardiac hypertrophy. Poultry Science. 2017b;96:2428-2437. Doi:10.3382/ps/pex015

How to cite this article

Banaa JJ, Barlian A, Ridwan A. Production performance of kampung hens fed rations containing black soldier fly larvae . Iran J Vet Sci Technol. 2023; 15(3): 48-56.
DOI: https://doi.org/10.22067/ijvst.2023.79438.1204
URL:https://ijvst.um.ac.ir/article_44250.html