Review Article

Effects of Using Black Soldier Fly Larvae Meal (*Hermetia illucens* L) as a Source of Protein on Boosting Performance, Carcass Quality, and Nutrient Digestibility of Village Chicken

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Abstract | The use of protein-based feed ingredients is crucial for the proper nutrition of chickens, but their availability is often limited, and their cost is typically high. Therefore, this study aims to develop a ration formulation using black soldier fly (BSF) larvae flour to reduce the use of fish flour and improve performance, carcass quality, and nutrient digestibility of village chicken. A total of 140 one-day-old chicks (DOC) were randomly assigned to one of five treatments in a completely randomized design, with four replicates per treatment. The treatments included P0 = 0% BSF larvae flour, P1 = 25% (3.74% BSF larvae flour), P2 = 50% (7.51% BSF larvae flour), P3 = 75% (11.26% BSF larvae flour), P4 = 100% (15% BSF larvae flour). The results showed that replacing fish flour with BSF larvae flour as a protein source in the brood diet of village chicken feed significantly ($P<0.05$) increased growth performance, live weight, carcass weight, carcass weight percentage, abdominal fat mass, abdominal fat percentage, and the digestibility of crude fat. Furthermore, BSF treatments increased (P=0.09) digestibility of crude protein and fiber. Based on these results, BSF larvae flour was recommended as an alternative protein source to replace fish meal in the diet of village chicken.

Keywords | BSF Larvae Flour, Village Chicken, Performance, Carcass Quality, Nutrient Digestibility

Received | January 23, 2023; **Accepted** | March 25, 2023; **Published** | June 01, 2023
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Citation | Auza FA, Purwanti S, Syamsu JA, Natsir A, Badaruddin R, Zulkarnain D, Munadi LOM (2023). Effects of using black soldier fly larvae meal (*hermetia illucens* l) as a source of protein on boosting performance, carcass quality, and nutrient digestibility of village chicken. J. Anim. Health Prod. 11(2): 193-198.
DOI | http://dx.doi.org/10.17582/journal.jahp/2023/11.2.193.198
ISSN | 2308-2801

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INTRODUCTION

There is a continuous increase in the growth of the animal husbandry industry in Indonesia, especially the poultry sector, due to the increasing demand for related products and population growth. The local village chicken plays an essential role in the lives of Indonesian and is associated with cultural development, especially in rural areas, where it is a major source of meat and eggs to fulfill the nutritional demands of the people. However, the development of local poultry in the country, especially village chicken, is still very slow compared to commercial chicken breeds. This condition is due to the relatively low genetic potential, inadequate management, and the use of traditional feeds with low quality (Nataamijaya, 2017). According to Budiansyah (2010), approximately 70-80% full-scale fabrication value of livestock business depends on the feed. Therefore, the optimal quality and quantity of feed are needed to improve growth.

One of the effects of Covid-19 is the disruption in the supply of mostly imported protein source feedstuffs, such as fish and soybean meal. These ingredients are required to formulate a ration containing balanced nutrition to meet the needs of poultry for optimal production. Consequently, the price of these feed ingredients is increasing. According to Beski et al. (2015), security threats to animal diet, environmental insistence, human inhabitant outgrowth, and increased demand for protein in the market have led to a rise in prices for animal protein in Indonesia. This makes it necessary to search for alternative protein-source feedstuffs.

Several studies had been carried out globally on the use of insects as a source of protein. According to Makkar et al. (2014), insects have considerable prospects due to their high nutrient contents such as protein, fat, carbohydrates, vitamins, and minerals. They are also organic waste converters and have several benefits such as being more economical, environmental friendly, and natural. Black soldier fly (BSF) larvae flour has a high protein level of 39-51% with fat ranging from 28 to 32% (Bosch et al., 2014). Park et al. (2014) stated that the biological characteristics of insects make BSF larvae flour rich in several types of antimicrobial peptides (AMP), exhibiting deterrent activity against pathogenic microorganisms. Therefore, this study aims to develop a feed formulation containing black soldier fly (*Hermetia illucens* L.) meal to reduce the use of fish meals and improve the productivity of village chicken.

MATERIALS AND METHODS

Experimental design and Feeding

This study used 140 one-day-old mixed-sex village chicken that were reared in 20 cages, each measuring 90 x 70 x 60 cm. The chicks (mean body weight: 29.64±1.69 g) were randomly selected in the individual cages, consisting of 7 birds per cage. The experiment comprised 5 treatments, with 4 replications, each consisting of 7 chicken, making a total number of 20 experimental units. The experimental rations were formulated using feed ingredients obtained mostly from the company around Makassar, except for BSF (*Hermetia illucens* L) larvae flour, which was purchased from BSF larvae Cultivation, Depok, West Java, Indonesia. The feed was provided *ad libitum* twice a day and the ND vaccine was administered at 3 days old through eye drops. The drinking water was freely available to chicken throughout the study. The feedstuff and nutrient structure of the experimental diets were observed, as presented in Table 1.

Nutritional Composition of BSF Larvae Flour

The chemical constituent of BSF larval flour compared to fish flour are provided in Table 2.

Sampling and Laboratory Analysis

BSF larvae and fish flour were sampled to determine their nutrition contents using proximate analysis (AOAC, 2005). To determine the quantity of feed ingested by chicken, the amount of feed offered was weighed every day, and the leftover feed was weighed the next morning before giving another. The feed consumption, weight gain and feed conversion rate were calculated as under:

Feed consumption (g) = the amount of feed offered (g) – the leftover feed (g)

Weight gain g/bird (gb^1) = final weight (gb^1) - initial weight (gb^1)

The feed conversion was calculated as body weight gain (g)/feed consumption (g)

The percentage of carcass and abdominal fat were measured at 12 weeks of age after slaughtering chicken. The percentage was calculated as follows:

Carcass Percentage = carcass weight (g)/ body weight (g) x100

Abdominal fat percentage = abdominal fat weight (g)/carcass weight (g) x100

In vivo digestibility measurements were carried out using an excreta collection method at the end of week 12. During this time, chicken were only given drinking water *ad libitum*. After the starvation period, chicken was fed *ad libitum* for 3 x 24 hours and starved again for 12 hours before taking the excreta samples which were brought to the laboratory to analyze crude protein, fiber, and fat (AOAC, 2005). *In vivo* digestibility of crude protein was calculated according to Wahju, (1997), while the calculation of crude fiber and fat digestibility was based on Tillman et al. (1998).

Statistical analysis

The data of all parameters for each treatment were analyzed by ANOVA in line with the study design. When the treatment was significantly effective (P<0.05), it was continued with Duncan's multiple intervals (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Performance of Village Chicken

Table 3 showed that the replacement of fish flour with BSF larvae flour had a significant effect (P<0.05) on the growth performance of village chicken. The average feed consumption ranged from 3063.60 to 3540.96 gb^{-1}. Similarly, Téguia et al. (2002) stated that broilers fed with a ration containing 15% BSF larvae flour consumed more feed than those fed with 10% of BSF. In our study, the P3 treatment had a higher weight gain compared to P0, P1, P2, and P4 treatments due to the higher feed consumption in the P3 treatment. Furthermore, the antibacterial compounds found in BSF larvae work probably synergistically

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Table 1: Composition and dietary analysis of village chicken diets consisting of BSF larvae flour

Feed ingredients (%)	Experimental diets				
	P0	P1	P2	P3	P4
Corn	64	64	64	64	64
Fine rice bran	12.5	12.5	12.5	12.5	12.5
Soybean meal	1	1	1	1	1
Fish meal	15	11.26	7.51	3.74	0
BSF larvae flour	0	3.74	7.51	11.26	15
Coconut cake meal	2.5	2.5	2.5	2.5	2.5
Vegetable oil	2	2	2	2	2
CaCO3	2	2	2	2	2
Vitamin-mineral Premix	1	1	1	1	1
Total	100	100	100	100	100
Chemical composition*					
Protein (%)	17.35	17.39	17.31	17.28	17.26
Fat (%)	2.42	2.80	3.38	3.86	4.35
Crude fiber (%)	6.22	6.54	6.87	7.18	7.53
Ca (%)	0.88	0.86	0.85	0.83	0.82
P (%)	0.82	0.72	0.62	0.5	0.4
Ash (%)	7.59	6.87	6.55	5.83	5.5
BETN (%)	52.67	48.44	48.17	47.80	47.64
ME (Kcal kg^{-1})	3063.16	3090.54	3117.92	3145.30	3172.68

* Projected based on the results and estimation of proximate analysis tables in the Feed Chemistry Laboratory, Faculty of Animal Science, Hasanuddin University.

Table 2: Chemical constituents of BSF (*Hermetia illucens* L.) larvae flour compared to fish flour

Chemical composition*	BSF larvae meal	Fish Meal
Dry Matter (%)	93.52	91.8
Crude Protein (%)	58.05	58.68
Crude Fat (%)	19.05	6.14
Crude Fiber (%)	9.31	0.56
Ash (%)	11.90	25.80
Ca (%)	1.28	1.70
P (%)	0.93	3.69
NaCl (%)	0.052	0.059
Metabolizable Energy (Kcal.kg^{-1})	2866.28	3596.40

*Analysis Results of Feed Chemistry Laboratory, Faculty of Animal Science, Hasanuddin University.

to promote growth. As in earlier work, Mbiba et al. (2019) reported that body weight gain in broilers was significantly (P<0.001) higher at 75% and 100% BSF larvae flour compared to ration containing no BSF. The higher protein intake in P3 treatment was due to the greater feed consumption value, leading to increased protein consumption, thereby causing an increase in body weight gain (Wati et al., 2018). This indicated that village chicken receiving P3 rations were more efficient at using nutrients to deposit meat into body weight. The average feed conversion value at the age of 90 days was 3.93-4.76. As compared to control group (4.76), T3 (3.93) exhibited 17.4% better FCR. This suggested that P3 treatment with the substitution of BSF larvae and fish flour slowed down peristalsis in the intestine. Dengah et al. (2016) also discovered that BSF larvae flour can substitute fish flour by 75% in diets without harming the feed efficiency of the broilers. In a recent study mealworm scales (*Tenebrio molitor*) supplementation in the diet of Japanese quails significantly improved the FCR and weight gain (Khan et al., 2022)

Carcass Quality of Village Chicken

The results of the analysis of various substitution levels of BSF larvae flour showed significantly (P<0.05) improved carcass quality of village chicken (Table 4). The average live weight in the P3 treatment was higher compared to others. This was due to the high ration consumption in the P3 treatment, i.e., 3540.96 g b^{-1}. The average percentage of carcass in village chicken aged 90 days were 58.06-70.70%, respectively, as presented in Table 4. These results were supported by Mbiba et al. (2019), where the percentage of carcass increased significantly in broiler chicken. Furthermore, carcass weight and percentage probably increased

Table 3: Effect of BSF larvae flour on the growth performance of village chicken.

Parameter	Treatments					P-Value
	P0	P1	P2	P3	P4	
Feed consumption (g b^{-1})	3117.46±157.87[a]	3071.34 ±38.08[a]	3063.60 ± 40.71[a]	3540.96 ±80.68[c]	3290.70± 82.39[b]	0.00
Weight gain (g b^{-1})	655.13 ± 46.66[a]	654.62 ± 24.66[a]	694.55 ± 18.27[a]	896.24 ± 69.26[b]	726.37 ± 46.31[a]	0.00
Protein intake (g)	595.82 ± 29.87[a]	586.76 ± 7.61[a]	586.30 ± 8.57[a]	676.33 ± 15.07[c]	628.77 ± 15.41[b]	0.00
Feed conversion ratio	4.76 ± 0.24[a]	4.56 ± 0.34[a]	4.53 ± 0.47[a]	3.93 ± 0.13[b]	4.52 ± 0.31[a]	0.02

Diverse letters in the same row represented significant distinction (P<0.05).

Table 4: Effect of BSF larvae flour on the live weight, carcass weight, and abdominal fat weight of village chicken.

Parameter	Treatments					P-Value
	P0	P1	P2	P3	P4	
Live weight (g b^{-1})	761.25 ± 35.09[a]	778.75± 44.96[a]	824.25± 75.75[a]	922.75± 35.55[b]	840.00± 64.74[a]	0.01
Carcass weight (g b^{-1})	442.00 ± 21.04[a]	492.75± 57.62[ab]	550.75± 29.73[bc]	583.25 ±41.31[c]	559.65± 42.75[c]	0.00
Percentage of carcass weight (%)	58.06± 0.95[a]	63.26± 6.21[ab]	66.91± 4.38[b]	70.70± 7.04[b]	69.42± 4.93[b]	0.02
Abdominal fat weight (g b^{-1})	10.70 ± 3.42[b]	8.67± 3.96[b]	4.10± 0.54[a]	3.72± 0.88[a]	2.30 ± 2.95[a]	0.00
Percentage of abdominal fat (%)	2.41± 0.71[c]	1.24± 0.59[b]	0.73± 0.11[ab]	0.63± 0.10[ab]	0.39 ± 0.48[a]	0.00

Diverse letters in the same row represented significant distinction (P<0.05).

due to the presence of lauric acid contained in BSF larvae in the form of Medium Chain Fatty Acid (MCFA), which can act as an antimicrobial in the active intestinal microbiota particularly for Gram-positive bacteria (Barros et al., 2014). The average percentage of abdominal fat in village chicken ranged from 0.39 to 2.41%, respectively. The highest weight and percentage of abdominal fat were found in the control treatment (P0), while the lowest was at P4. This was probably due to the crude fiber content in BSF larvae meal, which was 9.31%. Poendjiadi (2005) also stated that the consumption of crude fiber derived from feed ingredients binds bile acids in the digestive system, inhibiting fat absorption and decreasing the accumulation of abdominal fat.

Nutrient Digestibility

The crude protein digestibility showed no significant effect (P>0.05) but of the P3 treatment tended (P=0.09) to be higher than others, as illustrated in Table 5. Protein digestibility in this study ranged from 73.37 to 80.32%, which was categorized as high. This indicated that substituting fish meal with BSF larvae meal up to 100% improved the digestibility of crude protein. The degradation of chitin protein by the presence of AMP in the treatment feed improved intestinal balance, suppressed pathogenic microorganisms and improved the growth of beneficial bacteria such as *Lactobacillus* that results the synthesis of many digestible components, namely peptides and acids (Wang et al., 2006; Tang et al., 2009). Statistical analysis revealed that digestibility of crude fiber did not show any distinction among the treatments. The crude fiber digestibility in the P3 treatment tended (P=0.09) to be higher than others, with an average percentage ranging from 24.37 to 44.04%. This suggested an antibacterial activity in BSF larvae flour in the diet in the form of lauric acid. Skřivanová et al. (2014) reported that monolaurin compounds derived from lauric acid had antibacterial properties against *Staphylococcus aureus* and *Escherichia coli*. However, the crude fat digestibility showed a very significant difference (P<0.01), i.e., an increase in nutrient digestibility of village chicken. The average crude fat digestibility ranged was between 73.20% - 84.29%. These results were consistent with the study by Mbiba et al. (2019), who stated that using 75% to 100% maggot flour as a replacement for fish flour gave the best results of raw fat digestion. According to Sprangers et al. (2017), the fatty acid composition of BSF larvae flour was mostly saturated methyl fatty ester (FAME). Generally, the high fatty acid appearance of larvae was MCFA, such as lauric acid. This acid played an active role in regulation of Gram-positive bacteria, while MCFA exhibited antimicrobial effects on the gut microbiota (Dierick, 2002; Skřivanová et al., 2014). As also reported by Djulardi et al. (2006) that a decrease in the pH of the digestive tract due to an increase in lactic acid bacteria can increase lipase

Table 5: Effect of BSF larvae flour on the digestibility of crude protein, crude fiber, and crude fat in village chicken.

Digestibility (%)	Treatments					P-Value
	P0	P1	P2	P3	P4	
Crude Protein	73.37 ± 1.77	75.11 ± 4.13	76.46 ± 2.91	80.32 ± 4.10	77.519 ± 3.42	0.09
Crude Fiber	27.37 ± 11.71	31.44 ± 11.37	31.82 ± 2.59	44.04 ± 5.24	39.54 ± 8.73	0.09
Crude Fat	73.20 ± 2.67[a]	78.33 ± 2.84[b]	81.38±5.31[bc]	83.55 ± 1.28[c]	84.29 ± 1.88[c]	0.00

Diverse letters in the same row represented significant distinction (*P<0.05*).

enzymes as the end result of fat digestion.

CONCLUSION

The use of BSF larvae flour as a protein source to replace fish flour in village chicken diets increased growth performance, live weight, carcass weight, percentage of carcass weight, the weight of abdominal fat, percentage of abdominal fat, and digestibility of crude fat. The replacement of fish flour up to 75% with BSF larvae flour in the ration was considered the optimal feeding rate in increasing the use of feed ingredients without causing adverse effects on village chicken performance. Therefore, BSF larvae flour was suggested as a viable protein source to replace fish flour in village chicken rations.

ACKNOWLEDGMENTS

The authors are grateful for the discussions with Muhammad Syahrul and the generous technical assistance provided by members of his laboratory staff.

CONFLICT OF INTEREST

The research results are a mutual agreement, and there is no conflict of interest, be it funding and work.

NOVELTY STATEMENT

Feeding Uses of Black Soldier Fly Larvae can Improve Performance, Carcass Quality, and Digestibility of Free-range Chicken Nutrition.

AUTHORS CONTRIBUTION

FAA (Concept of research, laboratory work, data collection and data analysis), SP and JAS, (Laboratory work), AN (Edit and revise the manuscript) RB (Design concept), DZ and LMM (Write a script).

REFERENCES

AOAC. (2005). Association of Official Analytical Chemist. Official Methods of Analysis. Wahshington DC (US): Association of Official Analytical Chemist.

Barros-Cordeiro KB, Báo SN, Pujol-Luz JR (2014). Intra-puparial development of the black soldier-fly, Hermetia illucens. J. Insect Sci. (Online), 14(83): 1-10. https://doi.org/10.1093/jis/14.1.83

Beski SSM, Swick, RA, Iji, PA (2015). Specialized protein products in broiler chicken nutrition : A review. *Animal Nutrition*, 1(2): 47–53. https://doi.org/10.1016/j.aninu.2015.05.005

Bosch G, Zhang S, Dennis GABO, Hendrik WH (2014). Protein Quality of Insects as Potential Ingredients for Dog and Cat Foods. J. Nutrit. Sci., 3: 1–4. https://doi.org/10.1017/jns.2014.23

Budiansyah A. (2010). Performance of Broiler Chickens Given Rations Containing Coconut Meal Fermented by Tape Yeast as a Partial Replacement for Commercial Rations, 13(5): 260–268. https://doi.org/10.22437/jiiip.v0i0.43

Dengah, Sandi P, Umboh JF, Rahasia CA, Kowel YHS (2016). Pengaruh Penggantian Tepung Ikan Dengan Tepung Maggot (*Hermetia Illucens*) Pada Mawar Terhadap Kinerja Ayam Pedaging, Zootek, 3(1): 51–60. https://doi.org/10.35792/zot.36.2.2016.11499.

Dierick NA, Decuypere JA, Molly K, Beek EV, Vanderbeke E. (2002). The combined use of triacylglycerols containing medium-chain fatty acids (MCFAs) and exogenous lipolytic enzymes as an altervillage for nutritional antibiotics in piglet nutrition I . In vitro screening of the release of MCFAs from selected fat sources b, 75: 129–142. https://doi.org/10.1079/NRR200369

Djulardi A, H Muis, dan SA Latif. 2006. Nutrisi aneka ternak dan satwa harapan. Cetakan Pertama. Andalas University Press, Padang.

Khan S, Tanweer AJ, Rafiullah, Ibrahimullah, Abbas G, Khan J, Imran MS, Kamboh AA (2022). Effect of supplementation of mealworm scales (*Tenebrio molitor*) on growth performance, carcass traits and histomorphology of Japanese quails. J. Anim. Health Prod. 10(3): 381-389.

Makkar HPS, Tran G., Heuzé V, Ankers P (2014). State-of-the-art on use of insects as animal feed State-of-the-art on use of insects as animal feed. Anim. Feed Sci. Technol., 197: 1–33. https://doi.org/10.1016/j.anifeedsci.2014.07.008

Mbiba HF, Etchu KA, Ndamukong K. (2019). Performance of Broiler Chickens Fed Maggot Meal as a Protein Substitute for Fishmeal. J. Ethol. Anim. Sci., 2(1): 1-11. https://medwinpublishers.com/JEASc/JEASc16000109.

Nataamijaya AG (2017). Potensi Pengembangan Ayam Lokal untuk Mendukung Peningkatan Kesejahteraan Peternak, 29(4): 131–138. https://doi.org/10.21082/jp3.v29n4.2010.p131-138

Newton GL, Booram CV, Barker RW, Hale OM (1977). Dried Hermetia illucens larvae meal as a supplement for swine. *J Anim. Sci.* 44: 395-400. https://doi.org/10.2527/jas1977.443395x

Park SI, Chang BS, Yoe SM. (2014). Detection of antimicrobial

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substances from larvae of the black soldier fly, Hermetia illucens (Diptera: Stratiomyidae). Entomolog. Res., 44(2): 58–64. https://doi.org/10.1111/1748-5967.12050

Poendjiadi J (2005). *Biokimia Dasar.* Jakarta.

Sánchez-Muros MJ, Barroso FG, Manzano-Agugliaro F. (2014). Insect meal as renewable source of food for animal feeding: A review. J. Cleaner Prod., 65:16–27. https://doi.org/10.1016/j.jclepro.2013.11.068

Skřivanová E, Pražáková Š, Benada O, Hovorková P, Marounek M. (2014). Susceptibility of Escherichia coli and Clostridium perfringens to sucrose monoesters of capric and lauric acid. Czech J. Anim. Sci., 59(8): 374–380. https://doi.org/10.17221/7588-cjas

Spranghers T, Ottoboni M, Klootwijk C, Ovyn A, Deboosere S, Meulenaer BD, Michiels J, Eeckhout M, Clercq PD, Smet SD. (2017). Nutritional composition of black soldier fly (Hermetia illucens) prepupae reared on different organic waste substrates. J. Sci. Food Agricult., 97(8): 2594–2600. https://doi.org/10.1002/jsfa.8081.

Steel RGD, Torrie J (1980). Principles and Procedures of Statistics (Biometric Approach). 2nd edition.

Tang Z, Yin Y, Zhang Y, Huang R, Sun Z, Li T, Chu, W. (2009). Effects of dietary supplementation with an expressed fusion peptide bovine lactoferricin – lactoferrampin on performance, immune function and intestinal mucosal morphology in piglets weaned at age. 21: 101(7): 998–1005. https://doi.org/10.1017/S0007114508055633

Téguia A, Mpoame M, Okourou MJ (2002). The Production Performance of Broiler Birds as Affected by the Replacement of Fish Meal by Maggot Meal in the Starter and Finisher Diets. Tropicultura, 20(4): 187–192.

Tillman AD, Hartadi H, Reksohadiprodjo S, Prawirokusumo SLS (1998). *Nutrisi Ternak Dasar*. Gadjah Mada University Press, Yogyakarta.

Wahju J (1997). *Nutrisi Unggas* edisi 5. Gadjah Mada University, Yogyakarta.

Wang Y, Shan T, Xu Z, Liu J, Feng J (2006). Effect of lactoferrin on the growth performance, intestinal morphology, and expression of PR-39 and protegrin-1 genes in weaned piglets. J. Anim. Sci., 84(10): 2636–2641. https://doi.org/10.2527/jas.2005-544

Wati AK, Zuprizal, Kustantinah, Indarto E, Dono ND, Wihandoyo. (2018). Performa Ayam Broiler dengan Penambahan Tepung Daun Kaliandra (*Caliandra collthyrsus)* dalam pakan. Sains Peternakan, 16(2): 74–79. https://doi.org/10.20961/sainspet.v16i2.23260.

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