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Abstract. Black Soldier Fly (BSF) larvae (*Hermetia illucens*) is a feed that has a high protein content. The research aims to determine the role of the use of the BSF larvae the performance of a grower-phase poultry that substituted fish flour. A total of 120 4-week-old native chickens were alloted to 5 dietary treatments and 4 replications based on the completely randomized design. The treatment consists of P0 (basal rations + 100% fish flour), P1 (basal rations + 75% fish flour + 25% BSF larvae flour), P2 (basal rations + 50% fish flour + 50% BSF larvae flour), P3 (basal rations + 25% fish flour + 75% BSF larvae flour), P4 (basal rations + 100% BSF larvae flour). The parameters measured were the ration consumption, body weight gain, feed conversion ratio and protein consumption. The study showed that there were significant effect of treatment on feed consumption, the increasing of body weight and protein consumption. It concluded that feeding chicken the basal rations + 25% fish flour + 75% BSF flour can improve the performance of native chickens.

1. Introduction

Native chicken is a local chicken in Indonesia that has an advantage in high adaptation power because it is able to adjust to various situations. While the main problem in the development of native chickens is low productivity [1]. The increase in population and the level of poultry production needs to be offset by increased feed availability. In order to obtain fast chicken growth and high productivity, sufficient feed contains the necessary nutrients, both in quality and quantity. The completeness of nutrients is the most important thing in the preparation of rations. One of the most important things in the preparation of rations in livestock growth is protein. The needs of protein in chickens vary each period. In the grower phase requires a protein content of about 14% [2].

High protein content will result in expensive ration prices, so that rations that have high protein content at low prices continue to be pursued. The use of fishmeal as a high source of protein is well known. But it can also be lower when the components of the head and bones are more numerous, depending on which part is used [3]. Therefore, fishmeal can be replaced with other rationing materials as a source of animal protein without reducing the quality of rations. One of the alternative ration ingredients that is easy to get, cheap and can be used to replace fishmeal is to use a source of protein type insects [4].

One type of insects utilized is BSF with protein content of 40–50% [5]. Black soldier fly is reportedly an antibiotic because it contains antimicrobial peptide (AMP) [6] and lauric acid that can serve as natural antimicrobial agents [7]. BSF larvae also have an amino acid composition that resembles the amino acid composition in soybean meal or fish meal [8]. So, its use as a source of animal feed will mean double, namely its high protein content and antibiotic content to kill gram-positive and negative bacteria that are detrimental. Based on this potential, research on the use of BSF larvae flour in native chicken feed as an alternative source of conventional protein for native chicken. The purpose of this study was to determine the role of using maggot flour as a substitute for fish meal on the performance of the grower phase native chickens.

2. Materials and method

2.1. Maggot flour process

The research was conducted from February to March 2020 at the Poultry Livestock Production Laboratory, Faculty of Livestock, Universitas Hasanuddin, Makassar. BSF larvae used are obtained from maggot cultivation farmers in Depok, West Java. Then the dried maggots are ovenized at a temperature of 60°C for 24–48 hours, after drying is ground with a grinding machine to become maggot flour.

2.2. Cages and equipment

In this study, 20-unit cages were used. Each cage unit is equipped with a 10-watt incandescent lamp (as a heater). A week before the study was carried out, each unit of cage and equipment (place of feed and drink) was cleaned first. The lights are switched on at night with a cage temperature of 31–32°C to keep the cage temperature stable.

2.3. Rationing

The feed used in this study is grower feed in the form of basal feed in the form of mash consisting of yellow corn, soybean flour, fine bran, fishmeal, maggot flour, coconut meal, vegetable oil, $CaCO_3$ and premix. Rations and drinking water are administered ad libitum from 4 to 8 weeks.

2.4. Research variable

- Feed consumption (g/bird): feed consumption is calculated by the number of rations given minus the remaining feed divided by the number of chickens [8].
- Protein consumption (g): protein consumption is calculated by the amount of ration consumption multiplied by protein rations.
- Weight gain (g): weight gain is calculated from the weight of the last week the chicken is reduced by the initial weight of the chicken [9].
- Feed conversion ratio (FCR): FCR is obtained by dividing between feed consumption and weight gain [10].

2.5. Statistical analysis

The research was conducted using a completely randomized design with 5 treatments and 4 replications. Analyzed using Analysis of Variance (ANOVA) with a confidence level of 95% or $\alpha = 0.05$, if the treatment has a significant difference, followed by *Response* test.

3. Results and discussion

The average performance of native chickens with substitution of fishmeal with maggot flour (*Hermatia illucens*) in the feed phase of growers (4-8 weeks) in table 1.

3.1. Feed consumption

Table 1 shows that feed consumption of native chicken in basal ration + 25% fishmeal + 75% maggot flour obtained a noticeably higher of 1,348.08 g b^{-1} compared to other treatments. High feed

consumption value is caused by maggot flour having an antimicrobial peptide (AMP) content that is able to improve the morphology of the gastrointestinal tract and other compounds in the process of formation which have inhibitory properties against various types of pathogenic microorganisms [3,9]. Maggot or BSF extract has antibacterial activity against *Salmonella thypimurium*, *E. coli* and *Pseudomonas aeruginosa* [10]. While in the treatment of basal ration + 0% fishmeal + 100% maggot flour experienced a decrease in ration consumption. This is because maggots contain chitin compounds that can inhibit digestion. Thus. the administration of maggots with excessive amounts will inhibit the digestion of a livestock [11,12]. Low feed consumption of native chickens can occur because it can be broadly influenced by factors such as genetics. age and gender [13]. In addition to these factors. high consumption of rations may be influenced by other factors such as ambient temperature [14]. This is in line with the research reported [15] that the provision of BSF larvae flour up to 10% showed a decrease in the consumption of quail rations by 18.97 g b^{-1} d^{-1}. Apart from these factors. high ration consumption can be influenced by other factors such as ambient temperature [16].

Table 1. Performance of native chicken grower phase (28 day).

Treatment	Parameters			
	Feed consumption (g b^{-1})	Weight Gain (g b^{-1})	FCR	Protein consumption (g b^{-1})
P0	1,093.29±78.73	239.25±19.26	4.57±0.14	209.36±15.08
P1	1,081.65±12.88	234.24± 8.28	4.62±0.17	207.35±2.47
P2	1,080.61±62.35	239.35±19.69	4.54±0.54	207.37±11.96
P3	1,348.08±50.34	306.39±17.90	4.41±0.35	259.10±9.67
P4	1,253.61±37.22	267.64±26.43	4.71±0.34	241.19±7.16

Description: P0 (Basal ration + 100% fishmeal + 0% maggot flour). P1 (Basal ration + 75% fishmeal + 25% maggot flour). P2 (Basal ration + 50 % fishmeal + 50% maggot flour). P3 (Basal ration + 25% fishmeal + 75% maggot flour). P4 (Basal ration + 0% fishmeal + 100% maggot flour).

Table 2. Grower phase chicken performance response test.

Source	df	Sum of square	Mean square	F	Sig.	
Feed consumption						
-linier	1	137,859.30	137,859.30	48.63	0.00	*
-quadratic	1	3,022.17	3,022.17	1.07	0.32	
-qubic	1	5,5516.66	55,516.66	19.58	0.00	*
-quarter	1	45,098.99	45,098.99	15.91	0.00	*
Weight gain						
-linier	1	6,649.69	6,649.69	18.01	0.00	*
-quadratic	1	8.82	8.82	0.02	0.88	
-qubic	1	5,372.66	5,372.66	14.55	0.00	*
-quarter	1	2,754.41	2,754.41	7.46	0.01	*
Protein consumption						
-linier	1	5,327.52	5,327.52	51.07	0.00	*
-quadratic	1	113.46	113.46	1.09	0.31	
-qubic	1	2,054.61	2,054.62	19.69	0.00	*
-quarter	1	1,671.77	1,671.77	16.03	0.00	*

Note: *different significantly ($P<0.05$) (response test).

The amount of feed consumption can be influenced by several factors including environmental conditions, texture, shape, color and odor of feed, but from these factors the color and odor of the feed has different characteristics between the two treatment rations. BSF larvae flour has a darker color than fish meal but the use of fish meal substituted for maggot meal up to a level of 10% is in line with a study reported [17] that bright colors such as red and yellow give a response to aggressiveness and activity in poultry compared to dark colors. Thus, affecting the increase in the amount of feed

consumption. This was also confirmed by [18] who stated that the response to feed consumption was higher in yellow light treatment compared to blue.

Feed consumption response test in figure obtained a cubic equation relationship $Y = -0.002x^3 + 0.309x^2 - 9.506x + 1106$. $R^2 = 0.813$ of the equation obtained optimal maggot flour of 84% which is able to produce a maximum ration consumption of 1,302.392 g b^{-1}.

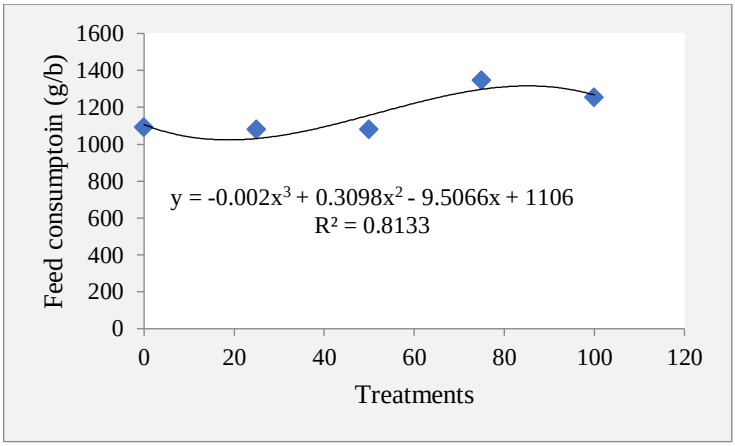

Figure 1. Maggot flour substitution level chart for feed consumption.

3.2. Weight gain

One of the nutrients that are important in gaining body weight is protein. Body weight gain is the ability of the chicken to convert the nutrients in the ration into meat. Table 3 shows that the increase in body weight of native chickens in P3 treatment obtained a high tangible yield of 306.39 g b^{-1} compared to other treatments. This is in line with the consumption of rations in P3 treatment which is 1348.08 g b^{-1} so that it is in line to produce weight gain as well. High ration consumption spurs faster growth resulting in higher weight gain [19]. Low weight gain in other treatments is due to low consumption of rations [20]. Low ration ingestion will result in low consumption of food nutrients. resulting in optimal growth that leads to decreased body weight [21]. This is different from the results of research [22] which stated that the use of BSF larvae flour up to a level of 10% in rations as a substitute for fish meal did not have an effect on body weight gain. this was probably due to the fact that the need for amino acids that had been met. for example methionine was also found. in some other ration mix ingredients such as soybean meal. bran and corn. In addition, the ration consumption obtained in his research also did not have a real effect so that it correlated with body weight gain.

Weight gain response test in figure 2 obtained cubic equation relationship $Y = -0.0006x^3 + 0.0921x^2 – 2,743x + 242.3$. $R^2 = 0.813$ of the equation obtained optimal maggot flour of 45.2% which is able to produce a maximum weight increase of 306.28 g b^{-1}.

3.3. Feed conversion ratio

The feed conversion ratio value is used to see how much the amount of feed consumption is to produce body weight in the same unit, this means that if the feed conversion is low and indicates that the feed quality is getting better. North and Bell [21] there are several factors that determine these variations, namely feed consumption, body weight, gender and age. Variance analysis results showed that the substitution of fishmeal with BSF maggot flour did not have a significant effect ($P>0.05$) on feed conversion. This is because ration consumption is not balanced with the resulting weight gain. Ration conversion value is influenced by the amount of ration consumption and weight gain [23]. As also Anggorodi [24] reported which states that the amount of consumption and body weight gain is directly proportional to the feed conversion value. In general, the FCR value correlates with the consumption value and the ability to absorb animal feed substances to produce body weight which is determined by the quality of the feed. The conversion value of the ration does not differ much between all treatments, but the conversion of rations in the treatment basal ration + 0% fishmeal + 100% maggot flour tends

to be higher which is 4.71 due to the administration of maggot flour with a level of 100% in rations, while maggot flour has an anti-nutrient substance of *chitin* compounds [25]. Poultry is a type of livestock that cannot produce chitinase enzymes that are tasked with degrading *chitin* [26] so that biological fermentation with Trichoderma time. can secrete hydrolytic enzymes such as *chitinase* that can degrade chitin [27]. The FCR values in this study varied and were included in the standard category, namely 4.41 – 4.71. This is in accordance with the research of [28] that the ideal feed conversion is 3.67–4.71.

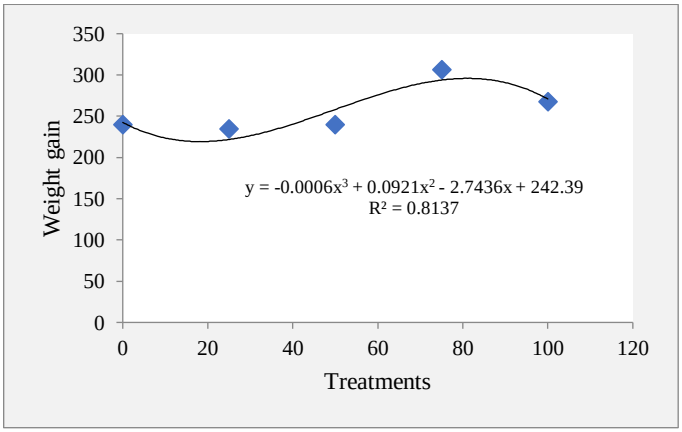

Figure 2. Maggot flour substitution level chart for weight gain.

3.4. Protein consumption

Table 1 shows that the consumption of protein in treatment P3 was higher, namely 259.10 g b^{-1} followed by P4 (241.19 g b^{-1}). P0 (209.36 g b^{-1}). P2 (207.37 g b^{-1}) and P1 (207.36 g b^{-1}). The high value of protein consumption in the P3 treatment was due to the fact that protein intake was influenced by the amount of ration consumption in the P3 treatment of 1,348.08 g b^{-1} and the presence of a more complete amino acid intake. so that it affected the increase in body weight.

The protein consumption response test in figure 3, obtained cubic equation relationship Y= -$0.0004x^3$ + $0.059x^2$ – 1.816x + 211.7, R^2 = 0.817 of the equation obtained optimal maggot flour of 47.6% which is able to produce a maximum protein consumption of 258.94 g b^{-1}

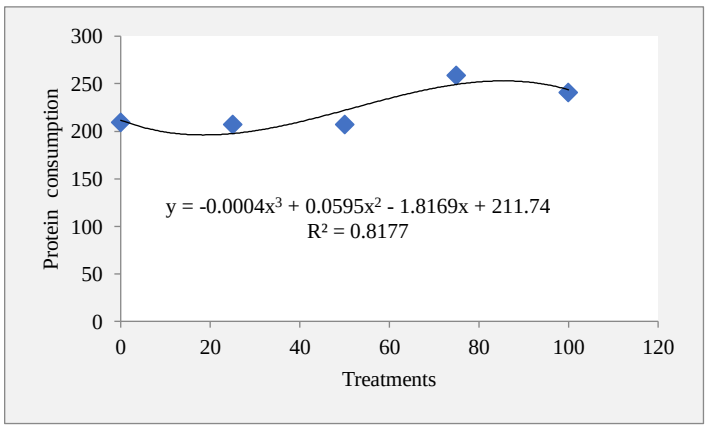

Figure 3. Maggot flour substitution level chart for protein consumption.

This is in line with research [29] which states that maggots or BSF larvae are also known to have a high amino acid content and are not much different from fish meal. There are even some amino acids that are higher in BSF maggots (*isoleucine, leucine, threonine*, *valine, phenylalanine* and *arginine).* Protein consumption is influenced by several factors, including live weight, age, physiological phase,

temperature, ration protein content and ration consumption [30]. The high value of consumption of this ration protein also causes weight gain [31]. This is in accordance with the opinion stated [32] that protein consumption is influenced by ration consumption, so that good ration consumption affects protein consumption which will affect protein intake.

4. Conclusion

It is concluded that the substitution of fishmeal with maggot flour (*Hermetia illucens* L) is best for the performance of native chickens in the grower phase is with the treatment of P3 (basal ration + 25% fishmeal + 75% maggot flour).

References

[1] Yuliana, Nuraini and Indi A 2017 Penampilan produksi ayam kampung yang diberi jamu ternak melalui air minum *JITRO* **4** 25–31
[2] Mulyono S 2004 *Beternak Ayam Buras Berorientasi Agribisnis* (Jakarta: Penebar Swadaya)
[3] Agustina L 2013 *Potensi Ayam Buras Indonesia* (Yogyakarta: Graha Ilmu)
[4] Simboh E N, Manangkot H J, Lambey L J dan Tangkau L M S 2017 Pemanfaatan manure hasil degradasi larva lalat hitam (*Hermetia illucens L*) sebagai pengganti tepung ikan terhadap penampilan ayam buras fase grower *Jurnal Zootek* **37** 395–402
[5] Bosch G, Zhang S, Dennis G A B O and Wouter H H 2014 Protein quality of insects as potential ingredients for dog and cat foods *J. Nutr. Sci.* **3** 1–4
[6] Choi S C, Ingale S L, Kim J S, Park Y K, Kwon I K and Chae B J 2013 An antimicrobial peptide-A3: effects on growth performance. nutrient retention. intestinal and faecal microflora and intestinal morphology of broilers *British Poult. Sci.* **54** 738–46
[7] Kim S A and Rhee M S 2016 Highly enhanced bactericidal effects of medium chain fatty acids (caprylic. capric. and lauric acid) combined with edible plant essential oils (carvacrol. eugenol. β-resorcylic acid, trans-cinnamaldehyde, thymol, and vanillin) against *Escherichia coli* O15 *Food Control* **60** 447–54
[8] Veldkamp T and Bosch G 2015 Insects: a protein-rich feed ingredient in pig and poultry diet *Anim. Front.* **5** 45–50
[9] Rasyaf M 2006 *Beternak Ayam Kampung* (Jakarta: Penebar Swadaya)
[10] Auza F A, Purwanti S, Syamsu J A and Natsir A 2020 Antibacterial activities of black soldier flies (*Hermetia illucens* L) extract towards the growth of *Salmonella typhimurium. E. coli* and *Pseudomonas aeruginosa IOP Conf. Ser.: Earth Environ. Sci.* **492** 012014
[11] Tipakorn N 2002 *Effect of Andrograpis paniculata (Burm.F) nees on performance, mortality and coccidiosis in broiler chickens* (Thailand: Faculty of Agricultural Sciences Institute of Animal Phisiology and Animal Nutrition)
[12] Sprangers T, Ottoboni M, Klootwijk C, Ovyn A, Deboosere S, De Meulenaer B, Michiels J, Eeckhout M, De Clercq and De Smet S 2016 Nutritional composition of black soldier fly (*Hermetia illucens*) prepupae reared on different organic waste substrates *J. Sci. Food Agric.* **97** 2594–2600
[13] Harefa D, Adelina dan Suharman I 2018 Pemanfaatan fermentasi tepung maggot (*Hermetia illucens*) sebagai substitusi tepung ikan dalam pakan buatan untuk benih ikan baung (*Hemibagrus nemurus*) *Jurnal Online Mahasiswa* **5**
[14] Widodo E 2018 *Ilmu Nutrisi Unggas* (Malang: UB Press)
[15] Suparman, Purwanti S and Nahariah N 2020 Substitution of fish meal with black soldier fly larvae *(Hermetia illucens)* meal to eggs production and physical quality of quail (*Coturnix coturnix japonica*) eggs *IOP Conf. Ser. Earth Environ. Sci.* **492** 012014
[16] Triawan A, Sudrajat D dan Anggraeni 2013 Performa ayam broiler yang diberi ransum mengandung neraca kation anion ransum yang berbeda *Jurnal Pertanian* **4** 73–81
[17] Widjaja H dan Haerudin R 2006 Rahasia Pancaindera Ayam *Majalah Trobos*
[18] Nascimento A V M, Giovann A P, Coldebella A, Jaenisch F R F, Filho J I S and Paiva D P 2011 Curtain color and lighting program in production: 1. General perfomance *R. Bras. Zootec* **40**

2026–34
[19] Nuningtyas Y F 2014 pengeruh penambahan tepung bawang putih (*Allium sativum)* sebagai aditif terhadap penambahan penampilan produksi ayam pedaging *Jurnal Ternak Tropika* **15** 21–30
[20] Fitasari E, Reo K dan Niswi N 2016 Penggunaan kadar protein berbeda pada ayam kampung terhadap penampilan produksi dan kecernaan protein *Jurnal Ilmu-ilmu Peternakan* **26** 73–83
[21] North M and Bell D D 1987 *Commercial Chicken Production Manual* 3rd Ed (USA: The Avi Publishing Company Inc)
[22] Yusuf M, Purwanti S and Mujnisa A 2020 Substitutions of fish meal with larvae meal black soldier fly (*Hermetia illucens*) on the performance of female quail *IOP Conf. Ser. Earth Environ. Sci.* **492** 012013
[23] Usman 2009 Pertumbuhan ayam buras periode grower melalui pemberian tepung biji buah merah (*Pandanus conoideus* LAMK) sebagai pakan alternatif *Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner* (Papua: Balai Pengkajian Teknologi Pertanian Papua) pp 599-604
[24] Anggorodi R 1990 *Ilmu Makanan Ternak Umum* (Jakarta: Gramedia)
[25] Marganov 2003 Potensi limbah *Crustacea* sebagai penyerap logam berat (timbal, kadmium dan tembaga) di perairan (Bogor: IPB)
[26] Mulyadi A, Suprijatna E dan Atmomarsono U 2017 Pengaruh pemberian tepung limbah udang fermentasi dalam ransum puyuh terhadap kualitas telur *Jurnal Agripet* **17** 95–103
[27] Vinale F, Sivasithamparan K, Gisalberti E L, Marra R, Wao S L and Lorito M 2008 Trichoderma plant pathogen interactions *Soil Biology and Biochemistry* **40** 1–10
[28] Al- Daraji H, Al-Mashadewi W K, Al-Hayani H A, Mirza and Al- Hassani A S 2010 Effect of dietary sipplementation with different oils on productive and reproductive performance of quail *Int. J. Poult. Sci.* **9** 429–35
[29] Hall H N, Neill H V M O, Scholey D, Burton E, Dickinson M and Fitches E C 2018 Amino acid digestibility of larval meal (*Musca domestica*) for broiler chickens **97** 1290–97
[30] Fanani A F, Suthama N dan Sukamto B 2014 Retensi nitrogen dan konversi pakan ayam lokal persilangan yang diberi ekstrak umbi dahlia (*Dahlia variabilis*) sebagai sumber inulin *Sains Peternakan* **12** 69–75
[31] Wati A K, Zuprizal, Kustantinah, Indarto E, Dono N D and Wihandoyo 2018 Performan ayam broiler dengan penambahan tepung daun *Calliandra calothyrsus* dalam pakan *Sains Peternakan* **16** 74–79
[32] Anggitasari S, Sjofjan O and Djunaidi I H 2016 Pengaruh beberapa jenis pakan komersial terhadap kinerja produksi kuantitatif dan kualitatif ayam pedaging *Buletin Peternakan* **40** 187–196