

Black Soldier Fly (*Hermetia illucens*) Maggot Flour as Concentrate Substitution on Broiler Chickens Feed Consumption, Body Weight Gain and Feed Conversion Ratio

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ABSTRACT

This study aims to determine the effect of concentrate substitution with maggot Black Soldier Fly (*Hermetia illucens*) flour on feed consumption, body weight gain and feed conversion ratio of broiler chickens. This study was an experimental study with a completely randomized design (CRD) with 5 treatment and 4 replications. The material uses broiler chickens age four weeks as many as 20 tails, the feed used is concentrate from the PT. Charoen Pokphand Indonesia, maggot BSF flour, corn and bran. The feed treatment with the addition of maggot BSF flour consisted of P0 (feed without maggot BSF flour), P1 (2% addition of maggot BSF flour), P2 (4% addition of maggot BSF flour), P3 (6% addition of maggot BSF flour), and P4 (8% addition of maggot BSF flour). From the study results obtained the mean and standard deviation of feed consumption, body weight gain and feed conversion of broiler chickens. Analisis of Variance (ANOVA) showed that the substitution of concentrate with maggot flour from black soldier flies had no significant effect ($p > 0.05$) on the feed consumption, body weight gain and feed conversion ratio of broiler chickens.

Keywords: Concentrate, maggot flour, feed consumption, weight gain, feed conversion ratio, broiler

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Introduction

Broiler chickens are one of the livestock commodities that produce nutrition and have very potential economic value. Apart from that, broiler chickens have advantages in terms of growth rate compared to domestic chickens in their classification (Alam *et al.*, 2020). Effendi *et al.* (2023) stated that broiler chickens have economic characteristics and fast growth as meat producers, low feed conversion, can be slaughtered when they are young and produce meat with soft fibers. Broiler chickens have a role in meeting people's nutritional

needs, because broiler chickens have quite a large protein content (Choi *et al.*, 2023). The success of a broiler chicken farming business is influenced by several factors, namely rations, seeds and medicines as well as appropriate marketing.

Chaparro and Dewey (2010) stated that the ration factor can be sought by utilizing ration ingredients that can be substituted for rations that are already sold in the market and these ingredients are ingredients that are available throughout the year, are easy to obtain and have biological value that can support the growth of broiler chickens.

A ration ingredient that is available but has not been widely used in rations, especially for poultry rations, namely maggots from the Black Soldier Fly (*Hermetia illucens*) can be used as an option for poultry rations as a protein source (Wang and Shelomi, 2017). Concentrate is a mixture of ration ingredients that are supplemented with the main food substances, such as protein, fat, carbohydrates, vitamins and minerals and have a low crude fiber content (Al-Suwaiegh et al., 2020).

Corn plants (*Zea mays* L.) are an energy source of ration material, namely around 50-55% of the total ration material (Ayasan et al., 2020). Rice bran is an agricultural waste ration material that is widely used for livestock rations, it is easy to obtain and the price is relatively cheap because rice bran is a by-product of rice milling (Ridla et al., 2023). Maggots are larvae that come from the Black Soldier Fly (*Hermetia illucens*). This maggot is a source of high animal protein because it contains quite high protein, around 40-50% (Bosch et al., 2014). The advantage of maggots as a ration ingredient is that they contain quite high levels of protein and fat. Several studies state that the nutritional content of maggots from the Black Soldier Fly (*Hermetia illucens*), includes: energy 5,282 KcalGE/kg, crude protein 42.1%, fat 26%, calcium 7.56% and phosphorus 0.9% (Makkar et al., 2014).

Maggots are one of the potential organisms that provide many benefits to humans as decomposers of organic waste. According to Indri et al. (2021), *Hermetia illucens* flies like the distinctive aroma of media, but not all media can be used as egg-laying places for Black Soldier Fly (*Hermetia illucens*). Decomposing organic waste using Black Soldier Fly (*Hermetia illucens*) larvae is very promising because the harvested larvae can be used as a protein source for animal rations, so they can be used as an alternative choice to replace conventional feed (Amrul et al., 2022). Growth rate is a function of nutrient levels. The better the level of nutrition provided, the better the growth rate, so that the efficiency of providing rations will have a real effect on increasing profits (Lifshitz et al., 2009).

When raising broiler chickens, feed consumption is something that must be considered because it is a basic need that has an effect on increasing body weight. The ration conversion ratio is a reference for the efficiency level of ration consumed during maintenance. The ration conversion ratio is obtained from the ratio of ration consumption to

production (body weight gain) within a certain time (Irwani et al., 2022). Based on the description above, the author wants to conduct research on the effect of concentrate substitution with Black Soldier Fly (*Hermetia illucens*) maggot flour on feed consumption, weight gain and feed conversion ratio in Cobb 500 finisher strain broiler chickens.

Materials and methods

Research design

This research was conducted in March–April 2022 at the Faculty of Veterinary Medicine, Airlangga University, Surabaya. Processing of rations and proximate analysis is carried out in the Animal Feed and Nutrition Laboratory and maintenance of experimental animals is carried out in the experimental animal cages of the Faculty of Veterinary Medicine, Airlangga University, Surabaya. The samples used in this research were broiler chickens (*Gallus gallus domesticus*) strain Cobb 500. Broiler chickens were given concentrate, corn and rice bran mixed with Black Soldier Fly (*Hermetia illucens*) maggot flour.

Ration mixing stage

The ration mixture in treatment P0 consisted of 30% concentrate, 60% corn, 10% rice bran and no maggot flour. In treatments P1, P2, P3, and P4 the ration composition is the same as P0 but the use of concentrate is substituted with maggot flour with concentrations of 2%, 4%, 6% and 8% respectively.

Experimental animals treatments

Chickens are given rations twice a day, namely morning and evening. The ration given is in the form of flour. Providing drinking water ad libitum. Before being given treatment feed, the broiler chickens were weighed first to determine the initial body weight of each broiler chicken (age 21 at the end of adaptation) and then the results were recorded. At the end of the treatment, the second weighing of the broiler chickens was carried out at 35 days of age.

Stage of calculating ration consumption

The remaining ration is taken every day for 2 weeks (14 x 24 hours) for each broiler chicken. The remaining rations are taken from the feed bin or what falls on the floor of the cage. The remaining ration is taken and weighted, the remaining ration weight data is used to calculate ration consumption.

Stage of calculating body weight

Body weight was measured at the beginning of treatment after adaptation and at the end of treatment to avoid the effects of stress on broiler chickens. Initial body weight measurements were carried out at the beginning of the study, while final body weight measurements were carried out at the end of the study. The calculation was carried out by calculating the difference in initial and final body weight during the study which was expressed in grams/head/day.

Stage of calculating the ration conversion ratio

The calculation of the feed conversion ratio value is obtained from calculating the feed consumption divided by the increase in body weight of the broiler chicken. The smaller the feed conversion value, the better the feed efficiency for broiler chickens.

Data analysis

The data obtained will be statistically analyzed using Analysis of Variance (ANOVA). If significantly different results are obtained then the Duncan Multiple Distance Test will be continued (Kusriningrum, 2012). Statistical analysis using the SPSS 21.0 for Windows program.

Result

Ration consumption

The average feed consumption (g/head/day) with ration feeding for 14 days in each treatment group respectively P0, P1, P2, P3, and P4 was 1142.25; 1147.25; 1149.25; 1148.00 and 1138.50 g/head. Based on the results of One Way ANOVA analysis and Duncan's Post-Hoc test, it shows that the substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot flour has no significant effect ($p > 0.05$) on ration consumption (table 1).

Table 1. Average and standard deviation of feed consumption in broiler chickens given concentrate substitution with Black Soldier Fly (*Hermetia illucens*) maggot meal for 14 days

Treatment	Feed consumption \pm SD (g/head)
P0	1142.25 \pm 9.639
P1	1147.25 \pm 11.701
P2	1149.25 \pm 9.032
P3	1148.00 \pm 6.480
P4	1138.50 \pm 2.380

Increase in body weight

Table 2. Average and standard deviation of body weight gain in broiler chickens given concentrate substitution with Black Soldier Fly (*Hermetia illucens*) maggot flour for 14 days

Treatment	Body weight gain \pm SD (g/head)
P0	424.75 \pm 58.863
P1	434.75 \pm 5.737
P2	410.50 \pm 56.015
P3	425.50 \pm 57.336
P4	403.25 \pm 74.033

The average body weight gain (g/head/day) by giving rations for 14 days in each treatment group successively P0, P1, P2, P3, and P4 are 424.75; 434.75; 410.50; 425.50 and 403.25 g/head. Based on the results of One Way ANOVA analysis and Duncan's Post-Hoc test, the substitution of concentrate with Black Soldier Fly maggot flour (*Hermetia illucens*) had no significant effect ($p > 0.05$) on chicken body weight gain (table 2).

Ration conversion ratio

The results of One Way ANOVA analysis and Duncan's Post-Hoc test showed that the addition of Black Soldier Fly maggot flour (*Hermetia illucens*) did not have a significant effect ($p > 0.05$) on the ration conversion ratio of broiler chickens (4.3). The average ration conversion ratio in the ration that was not given Black Soldier Fly maggot flour (*Hermetia illucens*) or P0 which was 2.72 was not significantly different from the ration conversion ratio in the ration substituted with Black Soldier Fly maggot flour (*Hermetia illucens*) respectively 2% (P1), 4% (P2), 6% (P3) and 8% (P4) which were 2.64; 2.84; 2.74 and 2.91 (table 3).

Table 3. Average and standard deviation of feed conversion ratio for broiler chickens given concentrate substitution with Black Soldier Fly (*Hermetia illucens*) maggot meal

Treatment	Ration conversion \pm SD
P0	2.72 \pm 0.345
P1	2.64 \pm 0.277
P2	2.84 \pm 0.401
P3	2.74 \pm 0.386
P4	2.91 \pm 0.637

Discussion

Ration consumption

Broiler chicken ration consumption is the ration consumed by broiler chickens from the start of rearing until harvest or the amount of ration given is reduced by the remaining ration. Calculation of ration consumption can be done every week when raising broiler chickens (Perween et al., 2016). Rations and feed consumption are one of the important factors to support the growth of broiler chickens, apart from that the ration must also meet the nutritional needs of broiler chickens (Lv et al., 2015).

Based on the results of analysis of variance (ANOVA), it shows that the substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot flour in broiler chickens did not provide a significant difference ($p > 0.05$) between treatments (P0, P1, P2, P3, P4) on consumption of broiler chicken rations. In this study, using treatments P0 (0%), P1 (2%), P2 (4%), P4 (6%) and P4 (8%) resulted in an average ration consumption of 1142.25 grams respectively (P0), 1147.25 grams (P1), 1149.25 grams (P2), 1148 grams (P3) and 1138.5 grams (P4).

Based on the opinion of Sharma et al. (2020) which states that the protein content and energy metabolism of different rations in a balanced state results in ration consumption levels that tend to be the same or not significantly different. The energy metabolism content in this study, respectively P0, P1, P2, P3 and P4, was 2461.78; 3445.32; 3428.88; 3412.43 and 3395.98 Kcal/kg. This is in accordance with the energy metabolism content stated by Khosinklang et al. (2023), namely a minimum of 3,100 kcal/kg, so it is still within normal limits and causes no significant differences in treatment.

According to Brandejs et al. (2022), the standard crude protein content in finisher phase broiler chicken rations is a minimum of 19%. The crude protein content in treatment rations P0, P1, P2, P3, P4 respectively was 20.18%, 20.23%, 20.3%, 20.36% and 20.42%. Based on these data, it can be seen that the crude protein content between treatments is almost the same so that the level of ration consumption in each treatment is not significantly different. Elahi et al. (2022), the use of insects in broiler chicken rations must be limited because of the chitin content. Most chitin cannot be digested by broiler chickens and results in undigested other nutrients, especially protein (Hossain and Blair, 2007). Chitin binds the amino acids that make up

proteins so that proteins become difficult to digest (Hamid et al., 2013).

Increase in body weight

Body weight gain is the difference between the final body weight (harvest) and the initial body weight at a certain time (Jacquier et al., 2014). According to Astuti and Wiryawan (2022) explains that body weight gain is an indicator of growth. The increase in body weight is closely related to ration, if the consumption of ration is disturbed then the increase in body weight of broiler chickens will also be disturbed (Flegal et al., 2009). Based on the results of analysis of variance (ANOVA), it shows that the substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot flour in broiler chickens did not provide a significant difference ($p > 0.05$) between treatments (P0, P1, P2, P3, P4) on increase in body weight of broiler chickens. The results of the research showed that the average increase in body weight was P0 of 424.75 grams/head, P1 of 434.75 grams/head, P2 of 410.5 grams/head, P3 of 425.5 grams/head and P4 of 403.25 grams/head.

In general, the increase in body weight of broiler chickens is influenced by the amount of feed consumed and the nutritional content of the feed (Rocha et al., 2022). The crude protein content in treatment rations P0, P1, P2, P3, P4 respectively was 20.18%, 20.23%, 20.3%, 20.36% and 20.42%. The results of the research did not show any significant differences in the body weight gain of broiler chickens because the nutritional content of the rations between treatments did not differ too much. As stated by French et al. (2017), rations that contain higher protein than others tend to provide higher body weight gain, while rations that contain low protein and consumed in small quantities can cause amino acid deficiencies or imbalances that inhibit growth. Apart from that, according to Huang et al. (2021) stated that the factors that influence body weight gain are gender, ration consumption, environment, seeds and ration quality.

Ration conversion ratio

The ration conversion ratio is a comparison between ration consumption and body weight gain obtained over a certain period of time. The ration conversion ratio can also be used to measure livestock productivity (Peters et al., 2014). Ciptaan et al. (2021) stated that a low ration conversion value indicates that the efficiency of using the ration is good, because the

more efficient the chicken consumes the ration to produce meat.

The research results show that the average ration conversion ratio is P0 2.72; P1 of 2.64; P2 of 2.84; P3 is 2.74 and P4 is 2.91. Based on these data, there was no real difference in ration conversion in this study, possibly influenced by several factors such as age, breed, nutritional content of rations, temperature conditions, condition of broiler chickens, management and use of good seeds (Zajac et al., 2020). Apart from that, according to the opinion of Shields and Greger (2013), genetics, ration quality, disease, temperature, cage cleanliness, air flow, medication and cage processing are also some of the main factors that influence the ration conversion ratio. Another factor that may have influenced the research results in that the feed conversion ratio variable was not significantly different was that feed consumption and body weight gain of broiler chickens in each treatment were not significantly different.

Conclusion

Based on the research results, it can be concluded that the substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot flour in the ration can maintain ration consumption in broiler chickens. Substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot meal in the ration can maintain body weight gain in broiler chickens. Substitution of concentrate with Black Soldier Fly (*Hermetia illucens*) maggot meal in the ration can maintain the ration conversion ratio in broiler chickens.

References

Al-Suwaiegh SB, Morshedy SA, Mansour AT, Ahmed MH, Zahran SM, Alnemr TM, Sallam SMA. Effect of an Essential Oil Blend on Dairy Cow Performance during Treatment and Post-Treatment Periods. *Sustainability*. 2020; 12(21): 9123.

Alam H, Ullah MO, Malik SUF, Islam MF. Broiler and indigenous chickens: A comparison through biochemical parameters. *Int J Sustain Agric Res*. 2020; 7(4): 228–233.

Amrul NF, Kabir Ahmad I, Ahmad Basri NE, Suja F, Abdul Jalil NA, Azman NA. A Review of Organic Waste Treatment Using Black Soldier Fly (*Hermetia illucens*). *Sustainability*. 2022; 14(8): 4565.

Astuti DA, Wiryawan KG. Black soldier fly as feed ingredient for ruminants. *Anim Biosci*. 2022; 35(2): 356–363.

Ayasan T, Cetinkaya N, Aykanat S, Celik C. Nutrient contents and in vitro digestibility of different parts of corn plant. *S Afr J Anim Sci*. 2020; 50(2): 302–309.

Bosch G, Zhang S, Oonincx DG, Hendriks WH. Protein quality of insects as potential ingredients for dog and cat foods. *J Nutr Sci*. 2014; 3: e29.

Brandejš V, Kupcikova L, Tvrdon Z, Hampel D, Lichovnikova M. Broiler chicken production using dietary crude protein reduction strategy and free amino acid supplementation. *Livest Sci*. 2022; 258; 104879.

Chaparro CM, Dewey KG. Use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings. *Matern Child Nutr*. 2010; 6(Suppl 1): 1–69.

Choi J, Kong B, Bowker BC, Zhuang H, Kim WK. Nutritional Strategies to Improve Meat Quality and Composition in the Challenging Conditions of Broiler Production: A Review. *Animals (Basel)*. 2023; 13(8): 1386.

Ciptaan G, Mirnawati, Djulardi A. Utilization of Fermented Soy-Milk Waste with *Aspergillus ficuum* in Broiler Ration. *IOP Conf Ser: Earth Environ Sci*. 2021; 709: 012044.

Elahi U, Xu CC, Wang J, Lin J, Wu SG, Zhang HJ, Qi GH. Insect meal as a feed ingredient for poultry. *Anim Biosci*. 2022; 35(2): 332–346.

Effendi S, Masir U, Ahmad I, Mariani. Analysis of the Cost of Maintaining Broiler Chickens with Herbal Feed. *Indones J Contemp Multidiscip Res*. 2023; 2(3): 423–432.

Flegal KM, Shepherd JA, Looker AC, Graubard BI, Borrud LG, Ogden CL, Harris TB, Everhart JE, Schenker N. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. *Am J Clin Nutr*. 2009; 89(2): 500–508.

French WW, Dridi S, Shouse SA, Wu H, Hawley A, Lee SO, Gu X, Baum JI. A High-Protein Diet Reduces Weight Gain, Decreases Food Intake, Decreases Liver Fat Deposition, and Improves Markers of Muscle Metabolism in Obese Zucker Rats. *Nutrients*. 2017; 9(6): 587.

- Hamid R, Khan MA, Ahmad M, Ahmad MM, Abdin MZ, Musarrat J, Javed S. Chitinases: An update. *J Pharm Bioallied Sci.* 2013; 5(1): 21–29.
- Hossain SM, Blair R. Chitin utilisation by broilers and its effect on body composition and blood metabolites. *Br Poult Sci.* 2007; 48(1): 33–38.
- Huang S, Sha S, Du W, Zhang H, Wu X, Jiang C, Zhao Y, Yang J. The association between living environmental factors and adolescents' body weight: a cross-sectional study. *BMC Pediatr.* 2021; 21(1): 572.
- Indri I, Sjam S, Gassa A, Dewi VS. Implication of types of feeds combined goat manure for preference black soldier fly (BSF): *Hermetia illucens* L. *IOP Conf Ser: Earth Environ Sci.* 2021; 807: 022085.
- Irwani N, Zairiful, Habsari IK. Feed Intake and Feed Conversion Ratio of Broiler Supplemented with Herb Extract. *IOP Conf Ser: Earth Environ Sci.* 2022; 1012: 012069.
- Jacquier M, Crauste F, Soulage CO, Soula HA. A predictive model of the dynamics of body weight and food intake in rats submitted to caloric restrictions. *PLoS One.* 2014; 9(6): e100073.
- Khosinklang W, Kubota S, Riou C, Kaewsatuan P, Molee A, Molee W. Omega-3 meat enrichment and L-FABP, PPARA, and LPL genes expression are modified by the level and period of tuna oil supplementation in slow-growing chickens. *J Anim Sci.* 2023; 101: skad267.
- Lifshitz F. Nutrition and growth. *J Clin Res Pediatr Endocrinol.* 2009; 1(4): 157–163.
- Lv M, Yan L, Wang Z, An S, Wu M, Lv Z. Effects of feed form and feed particle size on growth performance, carcass characteristics and digestive tract development of broilers. *Anim Nutr.* 2015; 1(3): 252–256.
- Makkar HPS, Tran G, Heuzé V, Ankers P. State of the Art on Use of Insects in Animal Feed. *J Ani Feed Sci.* 2014; 197: 1–33.
- Perween S, Kumar K, Chandramoni, Kumar S, Singh PK, Kumar M, Dey A. Effect of feeding different dietary levels of energy and protein on growth performance and immune status of Vanaraja chicken in the tropic. *Vet World.* 2016; 9(8): 893–899.
- Peters CJ, Picardy JA, Darrouzet-Nardi A, Griffin TS. Feed conversions, ration compositions, and land use efficiencies of major livestock products in U.S. agricultural systems. *Agric Syst.* 2014; 130: 35–43.
- Ridla M, Firdayanti, Laconi EB, Asikin N. Rice Bran Quality Based on Physical Properties and Chemical Composition Estimation in Maros Regency, South Sulawesi. *Indones J Anim Sci.* 2023; 33(2): 152–161.
- Rocha AG, Dilkin P, Neto RM, Schaefer C, Mallmann CA. Growth performance of broiler chickens fed on feeds with varying mixing homogeneity. *Vet Anim Sci.* 2022; 17: 100263.
- Sharma B, Nimje P, Tomar SK, Dey D, Mondal S, Kundu SS. Effect of different fat and protein levels in calf ration on performance of Sahiwal calves. *Asian-Australas J Anim Sci.* 2020; 33(1): 53–60.
- Shields S, Greger M. Animal Welfare and Food Safety Aspects of Confining Broiler Chickens to Cages. *Animals (Basel).* 2013; 3(2): 386–400.
- Wang Y-S, Shelomi M. Review of Black Soldier Fly (*Hermetia illucens*) as Animal Feed and Human Food. *Foods.* 2017; 6(10): 91.
- Zając M, Kiczorowska B, Samolińska W, Klebaniuk R. Inclusion of Camelina, Flax, and Sunflower Seeds in the Diets for Broiler Chickens: Apparent Digestibility of Nutrients, Growth Performance, Health Status, and Carcass and Meat Quality Traits. *Animals.* 2020; 10(2): 321.