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Effect of black soldier fly larva meal as a feed ingredient on metabolic energy, protein digestibility, production performance, characteristics, and carcass quality of local crossbred chickens

Black soldier fly larva meal sebagai bahan pakan ternak terhadap energi metabolis, kecernaan protein, penampilan produksi, karakteristik dan kualitas karkas ayam persilangan lokal

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A B S T R A C T

This research aims to determine the effects of Black Soldier Larva (BSF) meal on metabolic energy, protein digestibility, production performance, characteristics, and carcass quality of local crossbred chickens. The material for this research was 100 local crossbred chickens (the result of crossing male Kampung chickens with female laying hens) aged 30-35 days. The average initial body weight of chickens was 340.6 grams with a coefficient of variation of 5.24%. The research feed is a commercial feed for the finishing period. The experiment involved four treatment groups, where BSF larva meal was incorporated into the feed at levels of 0% (P0), 5% (P1), 10% (P2), and 15% (P3). The experimental design was a completely randomized design with four treatments and five replications. The research variables were metabolic energy, protein digestibility, feed consumption, body weight gain, feed conversion ratio, carcass percentage, and carcass quality. The data were subjected to an analysis of variance, and the differences between groups were determined by Duncan's test. Based on statistical analysis, BSF Larva meal influences breast muscle weight, meat protein content, apparent metabolic digestibility, and N retention. It can be concluded that BSF larva meal can replace 10% of complete feed without reducing production performance.

A B S T R A K

Tujuan penelitian ini adalah mengetahui penggunaan tepung BSF Larva Meal terhadap penampilan produksi, energi metabolis, kecernaan protein, penampilan produksi, karakteristik dan kualitas karkas ayam persilangan lokal. Materi penelitian ini adalah 100 ekor ayam persilangan lokal berumur 30-35 hari. Rata-rata bobot badan awal ayam adalah 340.6 g dengan koefisien keragaman 5.24%. Pakan penelitian menggunakan pakan komersial periode finisher. Perlakuan adalah penggunaan tepung BSF Larva dalam pakan dengan persentase 0% (P0), 5% (P1), 10% (P2), dan 15% (P3). Rancangan percobaan adalah Rancangan Acak Lengkap dengan empat perlakuan dan lima ulangan. Variabel penelitian adalah energi metabolis, kecernaan protein, konsumsi pakan, pertambahan bobot badan, konversi pakan, persentase karkas, dan potongan karkas. Data dianalisis menggunakan analisis sidik ragam, jika terdapat perbedaan dilanjutkan dengan uji Duncan's. Berdasarkan analisis statistik, penggunaan tepung BSF Larva memberikan pengaruh terhadap berat otot dada, kandungan protein daging, kecernaan metabolis semu, dan retensi Nitrogen. Tepung BSF Larva Meal dapat menggantikan 10% pakan lengkap tanpa menurunkan penampilan produksi.

Kata kunci:
SF Larva Meal
Karkas
Ayam lokal persilangan
Energi metabolis

INTRODUCTION

Poultry, such as chickens, is an important source of animal protein, producing eggs and meat. Local chickens can adapt to the hot weather and become more resistant to disease (Mariandayani, Darwati, Khaerunnisa, & Prasasty, 2023). The growing population of free-range chickens in Indonesia reached 314.1 million in 2022—a 2.52% increase from the previous year (Pratiwi, 2023) indicates the importance of poultry farming in the country.

The success of raising local crossbred chickens is influenced by feed and maintenance management. Sufficient feed in quality and quantity, according to the maintenance phase, will optimize the genetic potential. Commercial feed commonly used in raising chickens tends to increase over time. Non-conventional feed ingredients, such as novel resources, have the potential to be used as a source of animal protein (Rosmalah, Syamsinar, & Sufa, 2023). Black Soldier Fly Larva Meals are black soldier fly (Hermetia illucens) reared in agricultural or industrial waste media and harvested at the age of 35 days. Replacing some feed with BSF Larva Meal is an effort to increase production in local crossbred chickens and have a high enough nutritional content so they can be used as an alternative feed source for livestock, especially for poultry. BSF Larva Meal contains 7.0% crude fibre, 42.10% crude protein, 20.60% ash, 26.0% crude fat, and metabolic energy of 5,282 kcal/kg (Marbun, Tafsin, & Henuk, 2021).

Researchers have proven that BSF meal can replace 100% of the soybean meal in layer feed (Dörper, Veldkamp, & Dicke, 2021; Heuel et al., 2021). Research conducted by Seyedalmoosavi, Mielenz, Veldkamp, Daş, & Metges (2022) shows that the use of BSF larva meal up to 30% in feed does not affect feed consumption, nutritional intake, and body weight gain. In previous research, BSF meal was used on modern commercial chickens, but there was less information about BFS meal as a feed ingredient for local crossbred chickens. This study aims to evaluate the effects of BSF larva meal into poultry feed on metabolic energy, protein digestibility, carcass quality, and overall production performance in local crossbred chickens.

MATERIALS AND METHODS

The birds used in this research were 100 local crossbred chickens, aged 30-35 days, produced by PT Puncak Satwa Tulungagung. The average initial body weight of chickens was 340.6 g with a coefficient of variation of 5.24%. The research feed is a complete feed produced by PT Charoen Pokphand Indonesia. BSF Larva Meal is introduced to broilers in the finisher phase (29-55 days) considering the ability of the broiler's digestive tract to digest crude fibre and the high ether extract concentration.

Birds were kept in experimental plots made of bamboo measuring 1×1 m. One experimental unit contains five chickens. Incandescent lights are used at the beginning of rearing when the chickens are 1-29 days old. The feed provided is a complete starter-period chicken feed produced by PT New Hope with code 612. The vaccination program given during maintenance includes the ND Clone Life, ND AI Kill, Gumboro Life, ND IB Kill, and ND Coryza Kill vaccines. This vaccination program is one of the health programs for local crossbred chicken rearing.

Both the feed data collection and the excreta collection took place over the course of three days. During excreta collection, the collected excreta was cleaned from fallen food residue and loose feathers, and then spraying boric acid was carried out for 3 hours. The act of spraying boric acid serves to bind the nitrogen present in the excreta. Oxygen, boron, and hydrogen make up boric acid. It is claimed to have antifungal and antimicrobial properties. Laboratory analysis then takes place on the dried excreta (Islam, Haque, & Hossain, 2016).

After the excreta has been dried, it is ground (particle size<1 mm) and weighed. Excreta and feed will be analyzed for dry matter content, crude protein, and gross energy at the Food and Animal Nutrition Laboratory, Animal Science Faculty, Universitas Brawijaya, and Tidar Healthy Animal Clinic, Malang. This research analysis employs grams as the basic unit for dry matter.

The BSF larva meals used in the study were harvested at 35 days. Table 2 presents the results of the chemical analysis of commercial feed and BSF meal. Table 3 presents the composition of the feed ingredients and the nutrition of the treated feed. Figure 1 illustrates the procedure to produce BSF larva meal.

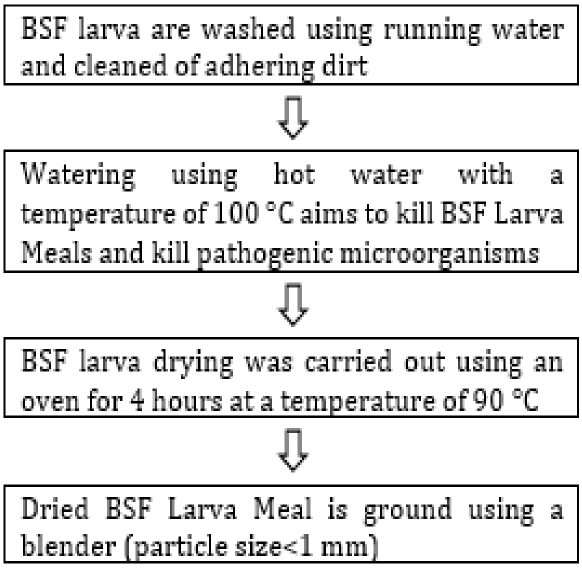

Figure 1. Procedure to produce BSF larva meal

Table 1. Chemical analysis of commercial feed and BSF larva meal

Chemical composition	Commercial Feed 1	BSF Larva 2
Metabolize energy (kcal/kg)	3,100.00	3,430.22
Crude protein (%)	19.00	26.53
Crude fiber (%)	5.00	45.72
Extract ether (%)	6.00	34.80
Ash (%)	7.00	8.53

Source: 1 Commercial feed label produced by PT. New Hope code 612, 2Proximate analyses of the Animal Nutrition and Food Laboratory (dry matter basic), Faculty of Animal Husbandry, Universitas Brawijaya (2022)

Table 2. Composition of feed ingredients and nutrition of treated feed

Feed ingredients	P 0	P 1	P 2	P 3
Commercial feed (%)	100	95	90	85
BSF larva meal (%)	0	5	10	15
Chemical composition 1				
Metabolize energy (kcal/kg)	3,100.00	3,116.51	3,133.02	3,149.53
Crude protein (%)	19.00	19.38	19.75	20.13
Crude fiber (%)	6.00	7.44	8.88	10.32
Extract ether (%)	5.00	7.04	9.07	11.11
Ash (%)	7.00	7.08	7.15	7.23

Note: Mathematical calculation

Method

The research method is experimental. The experimental design was a completely randomized design with four treatments and five replications. The research treatment was the use of BSF Larva Meal flour in feed with percentages of 0% (P0), 5% (P1), 10% (P2), and 15% (P3). The research variables are production performance including feed consumption, body weight gain and feed conversion, energy utilization, protein digestibility, and carcass quality including carcass weight, breast meat deposition, carcass cut weight (breast, upper thigh, lower thigh, back, and wings).

Research variable

The variables observed and measured in this research were feed consumption, final body weight, feed conversion, and carcass characteristics including carcass weight, carcass percentage, chest muscle weight, upper thigh, lower thigh, wings, and back. Carcass quality parameters include protein content, water-holding capacity, and cholesterol. Feed quality parameters include metabolic energy content, N-corrected metabolic energy content, protein digestibility, and nitrogen retention.

Protein digestibility is the amount of feed protein that is digested after consumption can be calculated using the formula (Maynard, 2018).

Protein digestibility (%) =
(Intake protein - Protein excreta)/(Protein intake)×100%

Apparent Metabolizable Energy (AME) is determined by (EM) is determined using an equation referring to (Octavia et al., 2018):

Apparent metabolizable energy =
Intake gross energy - gross energy excreta

Apparent Metabolizable Energy N-corrected (AMEn) Calculation of Corrected Energy N (AMEn) using an equation referring to (Octavia et al., 2018):

Apparent metabolizable energy N corrected =
Intake gross energy - gross energy excreta

Nitrogen retention is calculated using the equation according to:

N Retention = Intake N - N excreta

Data analysis

The data were subjected to an analysis of variance (ANOVA) using SPSS 16.0 software for Windows (SPSS Inc. Chicago, IL.USA). The differences between groups were determined by Duncan's multiple-range test. All values were presented as means and standard deviation, and significance levels were set as $P<0.05$ and $P<0.01$.

RESULTS AND DISCUSSION

Effect of treatment on feed quality: protein digestibility (%), apparent metabolizable energy (kcal/kg), apparent net metabolizable energy (kcal/kg), and N retention (g) presented in Table 3. The use of BSF larva meal on the production performance of local crossbred chickens and carcass quality is presented in Table 4.

Table 3. Effect of treatment on feed quality: protein digestibility (%), apparent metabolize energy (kcal/kg), apparent net metabolizes energy (kcal/kg), and N retention (g)

Parameters	P 0	P 1	P 2	P 3
Protein digestibility (%)	86.10 ±2.99b	80.76 ±4.56 ab	81.43 ±7.59 ab	74.33 ±5.62 a
AME (kcal/kg)	2543.75 ±30.22 b	2176.56 ±11.22 a	2142.42 ±15.07 a	2150 ±65.31 a
AMEn (kcal/kg)	2507.77 ±30.32 b	2144.01 ±10.11 a	2077.16 ±10.94 a	2141.60 ±66.15 a
Retention N(g)	3.40 ±0.42 b	3.15 ±0.32 ab	2.99 ±0.59 ab	2.31 ±0.40 a

Note: Superscript on the same row indicates significant differences ($P<0.05$)

Protein digestibility, apparent metabolizable energy, apparent net metabolizes energy and N retention

Table 4 displays data from the research on crude protein digestibility when BSF larva meal replaces some of the feed. The average crude protein digestibility from the research results is from the highest to the lowest: 86.10% (P0), 81.43% (P2), 80.76% (P1), and 74.33% (P3). The analysis of variance results show that adding BSF larva meal to some of the feed makes a significant difference ($P<0.05$) in the protein digestibility of local crossbred chickens.

The research results in Table 3. showed that protein digestibility has a significant effect ($P<0.05$) on protein digestibility. The nutritional content of BSF larva meal contains 41-42% crude protein. This aligns with the findings of Damara, Berata, Ardana, Setiasih, & Sulabda (2021), who assert that BSF meal has a high protein content of 42.65%, and that the protein content in the ration influences protein digestibility. The ration's

Table 4. BSF larva meal on the production performance of local crossbred chickens and carcass quality

Parameters	P 0	P 1	P 2	P 3
Production performance				
Feed consumption (g/bird)	8299.80 ±576.13	8293.80 ±218.55	7955.80 ±524.73	7808.20 ±608.08
Body weight gain (g/bird)	797.52 ±45.36	781.92 ±23.25	779.00 ±44.40	776.32 ±40.55
Feed conversion	10.44 ±1.20	10.60 ±0.50	10.22 ±0.61	10.08 ±0.71
Carcass characteristics				
Carcass weight (g/bird)	364.20 ±53.26	380.10 ±39.14	413.14 ±63.56	400.08 ±50.39
Carcass percentage (%)	45.51 ±4.50	48.67 ±5.58	52.99 ±7.35	51.56 ±5.11
Breast weight (g/bird)	50.20 ±4.13 a	56.86 ±6.20 b	55.26 ±0.37 ab	52.90 ±4.01 ab
Upper thigh (g/bird)	23.57 ±4.70	26.20 ±2.48	25.60 ±3.00	26.80 ±0.29
Lower thigh (g/bird)	93.10 ±23.17	88.66 ±16.80	102.86 ±18.38	102.90 ±18.34
Wing weight (g/bird)	87.94 ±13.61	83.98 ±8.86	95.82 ±16.09	92.68 ±12.62
Back weight (g/bird)	109.40 ±18.23	124.40 ±15.19	133.60 ±32.19	124.80 ±20.31
Carcass quality				
Protein (%)	15.28±4.68 a	15.21±2.06 a	17.21±2.21 ab	19.32±2.04 b
Water Holding Capacity (%)	28.00±6.65	30.40±9.45	33.75±4.35	25.03 ± 1.98
Cholesterol (mg/100 g)	16.66 ± 3.38	14.10±3.20	14.97±3.31	14.25±1.47
Tenderness (mm/10 sec)	13.92 ± 4.70	11.64 ± 2.89	10.58±1.99	7.84 ± 3.16

Note: Superscript on the same row indicates significant differences (P<0.05)

protein content influences protein digestibility. Rations that are low in protein have low digestibility. The level of protein digestibility depends on the protein content of the feed ingredients and the amount of protein that enters the digestive tract.

According to Pangaribuan, Hartono, Fathul, & Santosa (2022), two factors contribute to the high digestibility of crude protein in BSF larva meal. The first is the presence of non-protein nitrogen components, such as nucleic acids, chitin, excretion products, and phospholipids, which laboratory analysis measures as crude protein (B. Kim et al., 2022; Zegeye, 2020). However, the bodies of local crossbred chickens cannot utilize it; additionally, the presence of chitin, capable of forming complex bonds with protein, hinders the digestion of protein in their digestive tracts. BSF larva meals have a high protein content and other food substances, but they lack methionine and lysine. Therefore, experts recommend supplementing with methionine and lysine when substituting BSF larva meal for fish meal or soybeans in local crossbreed chicken rations (Marbun et al., 2021).

Table 3 shows that P0 has the best crude protein digestibility value. Replacing feed with BSF Larva Meal flour can reduce the crude protein digestibility. This is due to the absence of the chitinase enzyme in poultry, which makes feed supplemented with BSF Larva Meals indigestible. Poultry requires specific nutrients, particularly metabolic energy (EM) and protein, for their physical activity, metabolism, reproduction, production, and tissue formation (Pangaribuan et al., 2022). Metabolic energy requirement for super native chickens for the starter phase is 2,900 kcal/kg, while for super native chickens for the finisher phase, the metabolic energy required tends to be lower than the starter phase.

Energy is one of the feed nutrients that play a role in the growth phase of poultry. Low feed consumption can affect the formation of body tissue and the growth of birds. Less food consumption indicates a lower energy content in poultry. The energy in feed can impact the development of body tissue and the growth of birds (Latshaw & Moritz, 2009). Other factors that can influence feed consumption are the size and breed of chicken, environmental temperature, production stage, and energy in feed (Baracho, Nääs, Lima, Cordeiro, & Moura, 2019; Barszcz, Tuśnio, & Taciak, 2024).

Based on the results of the analysis of variance, it shows that the AME value of replacing part of the feed with BSF Larva Meal flour has a very significant effect (P<0.01). The apparent metabolism energy (AME) ranges from lowest to highest: 2142.42 kcal/kg (P2), 2,150.07 kcal/kg (P3), 2,176.56 kcal/kg (P1), and 2,543.75 kcal/kg (P0). In the process of preparing rations, it is crucial to understand the importance of metabolic energy. The nutritional content and balance of feed ingredients, along with the presence of crude fibre, significantly influence its value and determine the potential amount of metabolic energy. Therefore, the presence of crude fibre can reduce the digestibility of feed. High crude fiber can reduce the metabolic energy of feed by decreasing the digestibility of ingredients, which in turn leads to a decrease in the absorption of feed substances.

The digestibility and absorption of food substances closely correlate with metabolic energy levels. This is in line with what was reported by Musigwa, Morgan, Swick, Cozannet, & Wu (2021) and Sarwar, Akhter, Khan, Anjum, & Nadeem (2015), that metabolic energy is determined by the nutritional content, and the balance of ingredients and crude fibre is the main factor that determines the metabolic energy value. Latshaw & Moritz (2009) and Sibbald & Slinger (1963) stated the less energy expended by birds, the higher the ration that will be absorbed or digested, resulting in high ration energy use.

The research results, as presented in Table 3, indicate that even a 10% replacement of feed with BSF larva meal at P2 does not significantly increase the metabolic energy in the feed. The low value of apparent metabolic energy in the P2 treatment is due to the low gross energy content in BSF Larva Meals treated with P2. Birds that consume low-energy feed also experience low metabolic energy levels.

The gross energy of the feed and the amount of energy birds use influence metabolic energy digestibility. Standard nutritional requirements for metabolic energy depend on environmental temperature. The ability of poultry to consume rations reveals the mechanism for adapting to environmental temperature. There is a thermodynamic mechanism that controls the intake and expenditure of energy into and out of the body, which functions to stabilize body temperature (Musigwa et al., 2021; Sibbald & Slinger, 1963).

Table 3 shows that without replacing some of the feed with BSF larva meal, the best apparent metabolic energy (AME) value is at P0, indicating that feed not replaced with BSF larva meal can increase apparent metabolic energy. This is in line with the opinion of Siabandi, Bagau, Imbar, & Regar (2018) that increasing the use of BSF larva meal to replace some of the feed in the ration can lower the AME value of local crossbred chickens.

The results of calculating the metabolic energy of feed ingredients without N correction are considered to underestimate the energy value of a feed ingredient because nitrogen is stored in body tissues. Therefore, with the calculation of N-corrected metabolic energy, it is hoped that it will not be affected by N. The analysis of variance results show that giving BSF larvae food has a very big effect (P<0.01) on N-corrected energy metabolism (AMEn). The research results in Table 4 show that the N-corrected energy metabolism value from the partial replacement of BSF Larva Meal Flour feed from the lowest to the highest is 2,144.01 kcal/kg (P2), 2,141.60 kcal/kg (P3), 2,144.01 kcal/kg (P1), and 2,507.77 kcal/kg (P0). The chicken can almost completely utilize the energy in the feed, leading to the high metabolic energy value. The energy and protein content in feed and the amount of feed consumed will influence the amount of energy and protein consumed (Barszcz et al., 2024; Kovaleva, Demin, Kostomakhin, & Punegova, 2023).

Varianti, Atmomarsono, & Mahfudz (2017) assert that variations in protein levels in poultry feed can lead to variations in protein retention and metabolic energy values. Beski, Swick, & Iji (2015) state that if the protein quality is low or one of the amino acids in a feed ingredient is lacking, the nitrogen retention will be low. This is substantiated by a decrease in nitrogen retention resulting from an increase in protein content in the feed, possibly due to the utilization of only a small portion for energy purposes. This shows the importance of the energy needed; if the metabolic energy value is low, it will affect the nitrogen retention value, which decreases further.

N-corrected apparent metabolic energy value. Table 4 reveals that the P0 treatment, which does not replace part of the feed with BSF Larva Meal flour, yields the highest N-corrected metabolic energy value. However, the N-corrected metabolic energy value decreases at P2 (10%).

Marbun et al. (2021) provide support for this, asserting that substituting some of the feed in the ration with BSF Larva Meal Meal can lower the AMEn value of local crossbred chickens.

The analysis of variance shows that adding BSF Larva Meal flour to some of the feed has a real effect on the nitrogen retention value, which was 3.40 g (P0), 3.15 g (P1), 2.99 g (P2), and 2.31 g (P3) following that order. The balance of nitrogen (N) can be used to determine protein requirements for basic living, growth, and production and can be used to determine the quality of protein or the biological value of protein. Measuring nitrogen retention or using units like the biological value of protein efficiency ratio (PER) and nitrogen balance can determine the quality of protein in livestock rations (Varianti et al., 2017).

The value of the nutrient and energy content in the feed ingredients influences the difference in nitrogen retention values in each treatment. The higher the protein content of the feed, the higher the nitrogen retention value. The energy content of the feed influences the nitrogen retention value. Increased nitrogen retention signifies the digestion of more protein. The chicken's body can retain more nitrogen due to its ability to absorb more protein. The results indicate that high crude protein digestibility influences high nitrogen retention. Increasing protein in the ration can reduce nitrogen retention because some of it is used to meet energy needs.

Other factors that influence the RN value are ration consumption, protein consumption, protein quality, crude fiber digestibility, the balance of nutrients in the ration, and livestock conditions (Varianti et al., 2017). The opinion of Kim (2014); Kleyn, (2013); and Musigwa et al. (2021) supports that feed consumption and digestibility influence nitrogen retention in the bird's body. However, research shows that the nitrogen retention values at P1, P2, and P3 are the lowest. This occurs due to several factors, such as the physiological status of livestock and the process of fecal and urinary nitrogen excretion. The nutrient content of feed ingredients, the level of protein consumption, protein energy, the physiological status of birds, and the digestibility coefficient all influence the rate of faecal nitrogen excretion. Meanwhile, at P1, P2, and P3, there was a decrease in nitrogen retention due to the low crude protein digestibility values at P1, P2, and P3, as seen in Table 3.

The production performance and carcass quality

Average feed consumption was 1,659.96 g/bird (P0), 1,658.76 g/bird (P1), 1,591.16 g/bird (P2), and 1,561.64 g/bird (P3), respectively. This is thought to be caused by the nutritional content of P3 feed, which contains higher EM and PK, so the chickens will stop eating if the energy required has been met. This is in accordance with the statement Kim (2014); Musigwa et al. (2021); and Qiu et al. (2023) which states that changes in crude protein content in feed can affect production performance and ultimately will affect energy requirements, so that if there is a change in feed consumption, it is caused indirectly by changes in feed protein content. If all feed has the same protein percentage, feed with high EM will provide the bird's protein requirements due to the low amount of food consumed; if the energy content is low, the bird will consume food to get more protein, and the livestock will consume the feed needed.

Replacing some of the feed with BSF Larva Meal flour at 0%, 5%, 10%, and 15% resulted in an increase in the percentage of BSF Larva Meal flour; the amount consumed decreased due to the palatability of BSF Larva Meal flour. This is inversely proportional to research results Dörper et al. (2021); Kim et al. (2022); Marbun et al. (2021); and Seyedalmoosavi et al. (2022), which show that the greater the percentage of BSF Larva Meal feeding, the higher the level of feed consumption.

Research results indicate that digestibility also impacts the quantity of feed livestock consumes. This is in accordance with Bell & Weaver (2002) which states that feed can be consumed optimally if the digestibility can be tolerated by the birds, and the digestive and metabolic processes in the body are for livestock productivity during weight gain. The composition of the feed in each treatment is different, so feed consumption is also different. Data on feed consumption shows that local crossbred chickens consumed less feed when the percentage of BSF Larva Meal added to the feed increased. This reduction in the amount of feed consumed and the protein in the feed has an impact on the bird's body weight. Quality and quantity of feed consumed influence the increase in body weight. Differences in the content of food substances and the volume of feed consumed should influence body weight gain in poultry because a balanced content of feed substances is necessary for optimal growth. The increase in body weight of the animal indicates the livestock's ability to alter the food substances in the meat ration.

Based on research results, feed consumption at P3 tends to have the lowest feed consumption value, namely 1,561.64 g/bird. This low feed consumption value is thought to be due to the high energy content in P3 compared to control feed and other treatment feeds. The energy content of feed inversely correlates with the amount consumed; a high energy content leads to low feed consumption, while a low energy content leads to high feed consumption. Feed with lower metabolic energy will encourage broilers to increase feed consumption to meet their energy needs. The high level of crude fibre in P3, compared to other treated feeds, is believed to be another factor contributing to the low value of feed consumption. High crude fibre causes the rate of feed in the digestive tract to be slow. Crude fibre has bulky properties, meaning it fills the digestive tract of livestock and can inhibit the movement of food so that livestock feel full, stop eating, and cause feed consumption to decrease (Mait, Rompis, Tulung, Laihad, & Londok, 2019).

The results of statistical analysis showed that the treatment had no effect (P>0.05) on the final body weight of local crossbred chickens. This is following research results Pangaribuan et al. (2022), which stated that the provision of BSF larva meals in the feed of local crossbred chickens did not have a real effect on the final weight of the chickens. The final body weight of local crossbred chickens with the addition of BSF Larva Meal had an average weight for males of 884 g/bird and females of 793.33 g/bird.

The results of the research showed that the average feed conversion from the highest to the lowest values was, respectively, treatment P3, P2, P1, and P0. The results of statistical analysis showed that the treatment feed had no significant effect (P>0.05) on the feed conversion of local crossbred chickens. This is following the statement, which stated that the results of feeding with the addition of BSF Larva Meal to local crossbred chickens did not have a real effect on feed conversion. It is thought to be caused by higher weight gain due to the ration being higher in nutrition. Replacing some of the feed with BSF Larva Meal affects the levels of nutrients in the feed.

The research findings indicate that P0 yields superior results, potentially due to the high protein content in larval flour and its unique aroma, which in turn stimulates livestock's appetite. The statement Baracho et al. (2019) asserts that feeding relies on well-digestible food ingredients, as they effectively reduce feed waste. The high protein content in BSF Larva Meals, along with its unique aroma, stimulates birds' appetites for superior nutrition.

The results of the research show that P0 gives better results. It is thought that the high crude fibre content in larva meal means that the feed consumed makes birds feel full more quickly. This aligns with the findings of Pangaribuan et al. (2022), which suggest that supplementing with digestible feed, such as BSF larva meal, which is high in crude fibre and takes longer to digest, can lead to higher body weights and longer periods of fullness in birds. Providing vitamins also greatly influences livestock metabolism. This aligns with the assertion Baracho et al. (2019) that vitamin provision enhances feed conversion, improving metabolism, reducing feed consumption through effective absorption of feed components, and promoting optimal body weight gain.

Based on Table 4, using BFS larva has no effect (P<0.05) on carcass characteristics, including carcass weight, carcass percentage, and weight of carcass pieces consisting of upper thigh, lower thigh, wing, and back, but does influence the weight of breast pieces. Treatment P1 had the highest carcass weight, specifically the breast, at 56.86%, followed by treatments P2, P3, and P0. Nutrition plays a significant role in determining the carcass weight. Nutrition plays a crucial role in broiler production, as it significantly influences the chemical composition and quality of poultry meat. Some nutritional factors that are related are the choice of raw materials used to make feed, the chemical makeup of those materials, the differences in protein and energy values for making rations, the amount of nutrient utilisation, and the ways that the different parts of feed ingredients work together or against each other. A high feed protein content will contribute to a high meat protein content, but it will also result in a low fat content. Based on the nutritional aspect, chemical composition is an important element in determining the quality of poultry meat.

The increasing use of BSF larvae above 10% in feed indicates a decline in meat characteristics; this is due to the increase in crude fiber content in the form of silica and chitin. Some protein sources from the insect class have a high protein content, reaching 42-63%, but the fat content is also high, reaching more than 36%. Feed ingredients are sources of protein from insects deficient in methionine, lysine, and the mineral calcium. This resulted in the percentage of carcasses and the percentage of carcass cuts decreasing. Factors that affect carcass characteristics are strain, sex, and dietary protein. Research by Danisman & Gous (2011) found that the weight of carcass cuts, especially breast muscle, increased with increasing lipid intake and decreasing dietary protein but did not have a significant effect on other carcass cuts.

CONCLUSIONS

BSF larva meal has the potential to replace commercial complete feed up to a 15% level. It did not negatively impact the production parameters, characteristics, or carcass quality of local crossbred chickens, but it did have an impact on breast weight, carcass protein content, protein digestibility, metabolic energy, and nitrogen retention. It is recommended to introduce processing to eliminate the high chitin content in BSF larva meal.

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