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Characteristics of Quail Carcass and Non Carcass Fed A Diet with Black Soldier Fly Maggot Flour

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ABSTRACT

Feed is a crucial factor in enhancing quail (*Coturnix-coturnix Japonica*) productivity. A Frequently used protein source in quail feed is Meat Bone Meal (MBM). However, MBM is an imported product, making it relatively expensive. An alternative to MBM is utilizing locally sourced feed ingredients, such as black soldier fly maggot. This study aims to evaluate the characteristics of quail carcasses and non-carcass components from quails fed a diet containing black soldier fly maggot meal. The observed variables include slaughter weight, carcass weight, and its percentage, non-carcass weight and its percentage, commercial cut weight, and carcass percentage, as well as the weight and proportion of both edible and non-edible carcass components. The quail hens used in this study were aged 44-50 weeks and in their laying period. The research process included producing and managing black soldier fly maggot meal, preparing feed, setting up and maintaining cages, slaughtering, as well as cutting and deboning the carcasses. The treatment applied was R0 (feed with the primary protein source being MBM) and R1 (feed with the primary protein source of black soldier fly maggot). The collected data were analyzed using a two-sample t-test. The result showed that quail fed with black soldier fly meal as the primary protein source had no significant impact on slaughter weight, carcass and non-carcass percentage, commercial cut percentage, or the proportion of edible and non-edible parts. The conclusion of this study is that maggot can be used as an alternative protein source in feed as a substitute for MBM because quails fed with black soldier fly maggot flour as th eprimary protein source produced carcass and non carcass characteristics similar to those of quails fed with MBM as the main protein source.

Keywords: carcass, black soldier fly maggot, meat bone meal, non carcass, quail hen

ABSTRAK

Pakan merupakan faktor penting dalam meningkatkan produktivitas puyuh. Salah satu sumber protein yang umum digunakan dalam pakan puyuh adalah *Meat Bone Meal* (MBM). Namun, karena MBM merupakan produk impor, harganya relatif mahal. Sebagai alternatif, bahan pakan lokal seperti maggot *black soldier fly* dapat digunakan sebagai pengganti MBM. Penelitian ini bertujuan untuk mengkaji karakteristik karkas dan non-karkas puyuh yang diberi pakan dengan kandungan tepung maggot *black soldier fly*. Variabel yang diamati meliputi bobot potong, bobot dan persentase karkas, bobot dan persentase non-karkas, bobot dan persentase potongan komersial, serta bobot dan persentase bagian karkas yang dapat dimakan (edible) dan yang tidak dapat dimakan (non-edible). Penelitian ini menggunakan puyuh betina berumur 44-50 minggu pada fase bertelur. Prosedur penelitian meliputi pembuatan tepung maggot *black soldier fly*, persiapan pakan, persiapan kandang, pemeliharaan puyuh, penyembelihan, serta pemotongan dan pemisahan tulang pada karkas. Perlakuan yang diberikan adalah R0 (pakan dengan sumber protein utama MBM) dan R1 (pakan dengan sumber protein utama maggot *black soldier fly*). Data dianalisis menggunakan uji-t dua sampel. Hasil penelitian menunjukkan bahwa perbedaan sumber protein utama dalam pakan tidak memberikan pengaruh yang signifikan terhadap bobot potong, persentase karkas dan non-karkas, persentase potongan komersial, maupun persentase bagian karkas yang dapat dimakan dan tidak dapat dimakan. Berdasarkan hasil ini, tepung maggot dapat digunakan sebagai pengganti MBM dalam pakan, karena puyuh yang diberi pakan dengan tepung maggot *black soldier fly* memiliki karakteristik karkas dan non-karkas yang setara dengan puyuh yang diberi pakan berbahan utama MBM.

Kata kunci: karkas, *meat bone meal*, maggot, non karkas, puyuh

INTRODUCTION

Quail (*Coturnix-coturnix Japonica*) is a type of poultry with significant development potential in Indonesia. Quails are raised primarily to produce eggs for consumption. Besides producing edible eggs, quails also provide meat which is an affordable and readily available source of protein. The Directorate General of Livestock and Animal Health (2022) reported that quail meat production in Indonesia is declining annually. This decrease indicates a lack of public interest in both raising quails and consuming its products, especially the meat, even though it has higher protein content and lower fat in fat content compared to chicken meat (Kartikayudha *et al.* 2014). Male quails are utilized for meat, whereas hens are raised for their eggs. Quails begin to lay eggs at about 42 days old, with an initial egg production of 40%-60% (Arthur and Bejaei 2017). Quails have several advantages, including their adaptability to various environmental conditions, minimal land requirements for housing, and maintenance system (Ali *et al.* 2022).

The main factors influencing quail productivity include genetic and environmental factors. Generally, environmental factors include feed, maintenance management, and microclimate (Nagari and Sunarno 2022). Feed is crucial to achieve optimal quail productivity, therefore both the quantity and quality of feed must be controlled. One important factor that must be considered is the protein content in the feed. The quails need at least 17% protein in their feed during the egg-laying period (SNI 2006). A quail can lay more than 250 eggs per year, with egg weight is approximately 10 grams of egg-1 or 7%-8% of its body weight, reaching peak production at 4-5 months of age (Ali *et al.* 2022). Feed not only impact on egg production but also plays, an important role as it counts 60%-80% of the total expenses (Kurniati and Vaulina 2021).

Quail feed generally uses commercial feed. The protein source of quail commercial feed generally comes from Meat Bone Meal (MBM). The advantage of MBM is its relatively high protein content, which is 47.35% (Citra *et al*. 2019). However, since MBM is an imported product, its contributes to high cost of feed. MBM imports in Indonesia increased from 287 thousand tons in 2018 to 592 thousand tons in 2020 (GPMT 2015). MBM imports will continue to increase as the poultry population in Indonesia increases. Thus, alternative materials are needed to substitute for MBM. One of local feed ingredients that can be used as high protein feed source is black soldier fly maggot.

The black soldier fly maggot is a type of insect larva that is widely found and easy to breed. According to Azir *et al*. (2017), Black soldier fly maggots are a rich source of protein that can be incorporated into feed. Jayanegara *et al*. (2017) reported that black soldier fly maggot rich in nutrients, including, 44.9% crude protein, 29.1%crude fat, 16.4% crude fiber, and 8.1% ash content. The black soldier fly maggot also contains a complete composition of essential amino acids (Smeth *et al*. 2020). Proteins, made up of various amino acids plays crucial role in quail growth including muscle development, repair tissue, and formation of antibodies. Using black soldier fly maggots as an alternative replacement for MBM, is expected to reduce feedcosts. So far, several studies have explored the used of black soldier fly maggot in feed, there has been no research comparing the characteristics of carcasses and non carcasses of quails fed MBM as the main protein source versus those fed black soldier fly maggot. Therefore, further research on this topic is needed.

MATERIAL AND METHODS

Research Time and Location

The research was carried out from November 2023 to Maret 2024 at Arkan Quail Farm, located in Bogor District, West Java.

Equipment and Material

The materials used in this research included 100 quail (*Coturnix-coturnix Japonica*) in the egg laying period of 44-50 weeks, black soldier fly maggots, drinking water, and feed ingredients. The maggots were obtained from Will Maggot Farm in Leuwiliang, Bogor Regency. In addition, other equipment used in the research included 10 colony cages measuring 100 cm long, 75 cm wide, and 180 cm high, feed bin, drinking containers, thermometers, lamps, analytical scale, knife, data sheet, ziplock plastic bags, rubber bands, cutting board, and stationery.

Methods

This research's procedures has been approved by the Animal Ethics Committee School of Veterinary Medicine and Biomedicine, IPB University, with number 198/KEH/SKE/IV/2024. Black soldier fly maggot eggs were obtained from Will Maggot Farm in Leuwiliang, Bogor. A total of 30 grams of eggs were hatched in the medium made from chicken concentrate feed, that had been prepared into porridge, and were then reared for four days. The 4-day-old maggots are transferred to an enlargement medium of quail manure, where they are reared until 15 days of age, which is considered the optimal age for harvesting due to their best protein content (Citra *et al.* 2019). The maggots were cleaned and roasted using preheated black sand for 10-20 minutes to dry them (Dormants *et al.* 2021). After drying, the maggot is mashed and sieved to produce maggot flour.

The study feed consisted of two types, namely R0 (feed with MBM as the primary protein source) and R1 (feed with black soldier fly maggot as the primary protein source). Feed production is carried out in the feed industry laboratory, Faculty of Animal Science, IPB University. The nutrient content in the feed shown in Table 1 meets the nutrient requirement of quails during the egg-laying period. The standard crude protein content is at least 17%, the metabolic energy is at least 2700 kcal kg^{-1}, and the crude fiber is at most 7% (SNI 2006).

The rearing cages consisted of 10 plots, each containing 10 quails that were randomly assigned. Prior to the arrival of quail, cages and equipment were thoroughly cleaned and disinfected. Feeding and water were supplied ad libitum, once a day at 07.00 am, with daily records taken. Cage temperature and humidity were recorded three times

Table 1. The average temperature and humidity of the quail rearing environment over period of 30 days

Variable	Morning	Afternoon	Evening
Temperature (°C)	23.7-27.0	25.3-37.0	24.1-32.8
Humidity (%)	62-87	40-70	64-86
THI	26.7	36.3	32.5

THI : Temperature Humidity Indeks

a day. On the 30th day, when the quails were 50 weeks old, the slaughter weight was recorded and they were then slaughtered.

Prior to slaughter, the quails were fasted for 12 hours and kept hydrated to prevent dehydration. Fasting was done to empty the digestive tract, prevent contamination during slaughtering, and determine the empty slaughter weight. The quail was first weighed, then its legs were tied and it was hung with the head facing down. The quails were slaughtered by cutting the oesophagus, respiratory tract, and neck veins (SNI 2006). After the blood has stopped flowing, the quail were weighed again, skinned, and cleaned of offal, abdominal fat, head, neck, and legs, to obtain skinless carcass.

Carcasses were cut using the method outlined by of Card and Nesheim (1972). The skinless carcasses were cut into commercial sections including the breast, upper thigh, lower thigh, flank, and back. The commercially deboned carcasses were then processed by separating the meat from the bones.

The variables observed during the study included the characteristics of both carcass and non-carcass. The characteristics of carcass included cut weight, carcass weight and percentage, commercial cut weight and percentage, and edible and non-edible carcass weight and percentage. Non carcass characteristics included the weight and percentage of non carcass materials.

1. Cut weight (g^{-1}). This is measured at the end of maintenance period, just before cutting. Prior to weighting the cut weight of quail , the quail is fasted for 12 hours.
2. Carcass weight (g^{-1}). This is the body weight of the quail, weighed after removing the head, blood, internal organs, legs, abdominal fat, neck, feathers, and skin (g).
3. Percentage of carcass weight (%). This is calculated by deviding the weight of the skinless carcass (g) by the weight of the cut (g), then multiplying by 100%. The weight of a skinless carcass (g) is measured in grams by weighing the body parts of slaughtered quails after they have been separated from the non-carcass components.
4. Weight of the commercial cut of the carcass (g). This is obtained by weighing the individual cpmmercial cuts of the chest, upper thighs, lower thighs, wings and back (g).
5. Percentage of commercial carcass pieces (%). This is calculated by dividing the weight of commercial cuts (g) by the weight of the carcass (g), then multiplying by 100%.
6. The edible weight of the carcass is obtained by weighing the meat portion of the carcass (g).
7. Percentage of edible carcass (%). This is calculated by dividing the weight of edible carcass (g) by the weight of the carcass (g), then multiplying by 100%
8. Non edible carcass weight (g). This is measured in grams by weighing the non-edible carcass components, specifically the bones.
9. Percentage of non-edible carcass (%). This is calculated by dividing the weight of non-edible carcass (g) by the weight of the carcass (g), then multiplying by 100%.
10. Non carcass weight (g). This is the weight of blood, feather, skin, head, neck, legs, abdominal fat, heart, liver, gizzard, spleen, lungs, and intestines (g).
11. Percentage of non-carcass weight (%). This is calculated by dividing the non-carcass weight (g) by the cut weight (g), then multiplying by 100%.

Data Analysis

The treatments in this research were R0 (feed with MBM as the main protein source) and R1 (feed with black soldier fly maggot as the primary protein source). Each treatment was conducted five times, with 10 quails in each replicate. The data obtained were analyzedusing a t-test as described by Matjik and Sumertajaya (2013) :

$$t_{hit} = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

t : t-value;
$\bar{x}1$: average of quail treated with feed containing MBM;
$\bar{x}2$: average of quail treated with feed containing maggot;
S1 : standard deviation of quail fed diets containing MBM;
S2 : standard deviation of quail fed diets containing maggot;
n1 : number of quail samples fed with feed containing MBM; and
n2 : number of quail samples fed with feed containing maggot.

RESULTS AND DISCUSSION

General Condition of the Research Location

Air temperature and humidity were recorded during the 30-days rearing period under the same environmental conditions and time frame. The results of temperature and humidity recording for the maintenance environment are presented in Table 1. The ideal temperature for quail is between 20-25 °C (Safrika and Hamdani 2021), but during the study, temperatures frequently exceeded this comfort zone. The humidity in this study was above the optimal range for quail rearing. According to Santoso *et al.* (2022), the optimal humidity for quail rearing is between 50% and

70%. High temperature and high humidity make it difficult for quail to dissipate body heat, leading to heat stress. The THI indicator showed that in the morning, the condition was normal, but in the afternoon and evening, it fell into the emergency category. Heat stress causes quail to reduce feed consumption, resulting in suboptimal growth and a decrease in live weight, which is directly related to a reduction of carcass weight.

Cut Weight, Carcass Weight, and Non Carcass Weight

The results of statistical analysis showed that the initial weight, slaughter weight, carcass weight percentage and non-carcass weight of quails fed with MBM protein source (R0) and black soldier fly maggot meal (R1) did not differ significantly (Table 2). This similarity was attributed to comparable feed consumption, nutrient content, amino acid intake, and rearing environmental conditions in both treatments. This is consistent with Ahdanisa *et al.* (2014) who stated that the slaughter weight did not differ due to the same balance of feed energy and protein. In addition, nearly identical feed consumptioncontributed to a similar growth rate (Prakash *et al*. 2020). Horhoruw and Rajab (2019) stated that rearing the quails in the same environment, cage, and with the same feed will result in similar slaughter weights. The slaughter weight in this research was less than the finding of Lotfi *et al.* (2011), who reported a slaughter weight of 232.4 grams per head in 42-day-old quails. This difference was due to the higher feed protein content (20%) and optimal rearing temperature (20 °C) in the study by Lotfi *et al.* (2011). This conditions prevented the quails from experiencing heat stress and promoted increased metabolism, resulting in higher slaughter weight.

Table 2. The average initial weight, slaughter weight, carcass and non-carcass weight and their respective percentage of quail

Variable	R0	R1
Initial weight (g ekor $^{-1}$)	190.00 ± 9.66	189.38 ± 3.11
Cutting weight (g ekor $^{-1}$)	179.84 ± 17.50	164.88 ± 10.64
Skinless carcass weight		
(g ekor $^{-1}$)	92.75 ± 8.36	82.56 ± 2.50
(%)	51.57 ± 2.49	50.08 ± 2.18
non carcass weight + skin		
(g ekor $^{-1}$)	87.09 ± 6.45	82.32 ± 12.49
(%)	48.43 ± 3.02	49.92 ± 7.01

R0 = feed with MBM as the primary protein source, R1 = feed with black soldier fly maggot as the primary protein source

The initial weights between R0 and R1 treatments were almost the same. Based on calculations, the proportion of cut weight for R1 was lower than that of R0, with R1 at 87.06% and R0 at 94.65% of the initial weight. This situation may be caused by the feed in R1 contains black soldier fly maggot, which has a higher total crude fiber. This is because the black soldier fly maggots contain chitin in their body. Higher crude fiber can interfere with protein digestion. Kastalani *et al*. (2021) reported that maggots, as a type of insect, have a limiting factor in their body, namely chitin, which can form complex bonds with proteins, preventing them from being digested properly in the digestive tract of poultry. The chitin content of maggot can be minimized by sieving to separate from the peeling skin before making maggot flour.

Belluco *et al.* (2013) also stated that feed ingredients derived from insects contain chitin, which may decrease digestibility. Sanchez and Muros (2014) added that the absence of a cellulose enzyme in poultry, which are also monogastric animals, results in suboptimal digestion of feed containing additional maggot. Therefore, in this study, the resulting cut weight at R1 is lower than that of R0.

The results of statistical analysis indicated that no notable difference was observed in the carcass percentage between quails fed with the main protein source, MBM (R0) and, those fed with black soldier fly maggots (R1). This was because both diets contained similar nutrient composition, with 17.8% protein and nearly the same energy content (2.948 kcal/kg). Anggitasari *et al.* (2016) stated that there is a linear correlation between protein, energy, and carcass percentage. The protein and energy in feed are used to produce meat in the body. In addition to the nutrient content of the feed, carcass percentage is also influenced by cutting weight. When cutting weights are similar, the resulting carcass percentage are also similar.

The average percentage of non-carcass weight between quail fed diets with MBM as the main protein source (R0) and black soldier fly maggot (R1) did not differ significantly, as the non-carcass weights of both treatments were nearly identical. When non-carcass weight adjusted based on slaughter weight, the results remained the same. The non-carcass percentage in this study was higher than the carcass percentage. Zayed *et al.* (2019) stated that the non-carcass percentage is inversely related to slaughter weight meaning that as the carcass percentage increases, the non-carcass percentage decreases. This indicated that maggot can be used as the main protein source to replace MBM because it does not affect the percentage of carcass and non-carcass quail and can reduce feed costs because it is sustainable.

Carcass Components

Commercial deductions refer to deductions that hold economic value. Table 3 presents the analysis results of the average percentage of commercial carcass cuts from quails fed with MBM (R0) as the primary protein source and those fed with black soldier fly maggots (R1) as the primary protein source. There was no significant difference in the mean percentage of commercial cuts (breast, upper thigh, lower thigh, wing, and back without skin) between treatments R0 and R1. This suggests that the development of animal body parts is similar, as the feed provided contains comparable nutritional content, particularly in term of protein, energy, and minerals (Nita *et al*. 2015). Commercial cuts are also influenced by slaughter weight (Dwiky *et al.* 2017), which explains why the results show no differences in slaughter weight and carcass, reflecting similar percentage in carcass parts. The percentage of breast is the highest because the chest is not involved in locomotion, allowing for greater

Table 3. The average percentage of commercial cuts of the quail carcass

Variable	R0	R1
Chest (g)	40.64 ± 5.11	36.01 ± 3.09
(%)	43.81 ± 6.31	43.62 ±3.99
Upper thigh (g)	11.05 ± 2.25	9.69 ± 1.07
(%)	11.91 ± 2.45	11.74 ± 1.46
Lower thigh (g)	10.06 ± 0.62	9.91 ± 0.32
(%)	10.85 ± 0.73	12.00 ± 0.44
Wings (g)	5.36 ± 0.81	5.43 ± 0.51
(%)	5.78 ± 1.12	6.58 ± 0.68
Back (g)	25.64 ± 2.05	21.52 ± 1.72
(%)	27.65± 2.28	26.06 ± 2.48

R0 = feed with MBM as the primary protein source, R1 = feed with black soldier fly maggot as the primary protein source

Table 4. The average percentage of edible and non-edible quail carcasses

Variable	R0	R1
Meat (g)	66.03 ± 4.96	61.50 ± 4.64
(%)	71.19 ± 3.58	74.49 ± 5.75
Bone (g)	26.72 ± 3.71	21.06 ± 3.64
(%)	28.81 ± 3.37	25.51 ± 5.18

R0 = feed with MBM as the primary protein source, R1 = feed with black soldier fly maggot as the primary protein source

muscle and fat, development, with more energy stored as meat and fat (Tian *et al.* 2021).

The edible carcass refer to the part of the carcass that includes the meat and fat attached to it, while the non-edible carcass consists of the bone components. Table 4 displays the statistical analysis results for the average percentages of edible and non-edible carcass components. The average percentage of edible carcasses (meat) in quail fed with protein sources of MBM (R0) and black soldier fly maggot (R1) were 71.19% and 74.49%, respectively, with no significant difference observed. This is because the nutritional content, especially protein, in MBM and black soldier fly maggot is nearly identical, leading to a similar daily protein intake in both treatments. According to Dasir and Yani (2020) protein is a key component in the formation of edible carcasses (meat). As a result, the percentage of edible carcasses from both treatments did not show any significant difference.

The average percentage of non-edible carcass (bone) in quail fed with MBM (R0) and black soldier fly maggot (R1) was 28.81% and 25.51% (Table 4), respectively, with no significant difference observed. This is due to the similar calcium and protein content in both feeds, with calcium intake at 0.44 grams/head/day for R0, and 0.54 grams/head/day for R1, resulting in comparable bone growth. Calsium is the main component in bone formation, and protein also plays a by binding calcium to be deposited in the bone (Lisnahan and Nubatonis 2021). The nearly identical intake of protein and calcium causes similar bone growth.

Non Carcass Components

The non-carcass parts of quail in this research included blood, viscera, head, neck, abdominal fat, legs, feathers and skin (Table 5). The t-test results indicated that replacing MBM with black soldier fly maggot as the main protein source did not significantly affect the percentage of non-carcass components. This is because the nutrition contents in both feeds met the quails' requirements (Hutama *et al.* 2014), and the similar slaughter weights also contributed to the lack of difference in percentage of non-carcass components (Praing *et al.* 2022). Feeding maggot meal did not affect quail organ function.

Table 5. The average percentage of non-carcass components

Variable	R0	R1
Blood (g)	8.71 ± 1.64	8.04± 1.67
(%)	4.85 ± 0.83	4.87 ± 0.94
Fur + skin (g)	48.48 ± 3.75	46.25 ± 1.09
(%)	27.14 ± 3.05	27.59 ± 1.63
Foot (g)	3.76 ± 0.26	3.84 ± 0.36
(%)	2.10 ± 0.12	2.33 ± 0.16
Neck (g)	4.03 ± 0.40	4.27 ± 0.45
(%)	2.25 ± 0.26	2.57 ± 0.25
Head (g)	6.41 ± 0.16	6.48 ± 0.78
(%)	3.60 ± 0.41	3.68 ± 0.74
Total offal (g)	15.24 ± 2.32	12.92 ± 2.63
(%)	8.43 ± 1.85	8.48 ± 1.18
Liver (g)	4.88 ± 0.70	3.91 ± 0.53
(%)	2.71 ± 0.31	2.72 ± 0.66
Heart (g)	1.43 ± 0.18	1.18 ± 0.19
(%)	0.80 ± 0.12	0.98 ± 0.63
Gizzzard (g)	2.61 ± 0.21	2.59 ± 0.37
(%)	1.45 ± 0.04	1.61 ± 0.28
Intestines (g)	5.04 ± 1.57	4.08 ± 0.77
(%)	2.76± 0.76	2.50 ± 0.40
Lungs (g)	1.09 ± 0.17	0.97 ± 0.21
(%)	0.61 ± 0.11	0.58 ± 0.12
Lymph (g)	0.19 ± 0.06	0.19 ± 0.06
(%)	0.10 ± 0.03	0.09 ± 0.05
Abdominal fat (g)	0.46 ± 0.57	0.51 ± 0.64
(%)	0.30 ± 0.31	0.30 ± 0.41

R0 = feed with MBM as the primary protein source, R1 = feed with black soldier fly maggot as the primary protein source

CONCLUSION

Quails given feed with black soldier fly maggot meal and MBM as the main protein sources exhibited similar carcass characteristics (cut weight, carcass weight percentage, non-carcass weight percentage, commercial cut percentage, edible and non-edible carcass percentage) and non-carcass characteristics (non-carcass component percentage). Black soldier fly maggot serves as a viable alternative primary protein source that can potentially replace MBM in quail diets. Maggot is proven to give the same results in carcass and non-carcass percentages, so it can be a more environmentally and economically friendly option in the quail farming industry.

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