e-ISSN 2808-2311
The 6th National Conference of Applied Animal Science 2025

Department of Animal Science
Politeknik Negeri Jember

Jember, September 25-26
doi: 10.25047/animpro.2025.875

Nutritional assessment of maggot meal as an alternative protein in broiler starter diets

Penilaian nilai gizi tepung maggot sebagai alternatif protein dalam pakan starter broiler

Ilanka Citra Buana Maha Dewi[1,] Listya Purnamasari[1*], Desy Cahya Widianingrum[1], dan Himmatul Khasanah[1]

[1]Animal Husbandry Study Program, Faculty of Agriculture, University of Jember, Jalan Kalimantan 37, Jember Indonesia 68121
*Corresponding Author's Email: listyap.faperta@unej.ac.id

Abstrak. *Proper feed formulation is needed to meet the needs of the necessary food substances in sufficient quantities to support livestock productivity. Starter phase broilers have the highest crude protein requirement because it is an important growth phase in muscle and body tissue formation. Broiler chickens have a good ability to utilize nutrients through alternative feed as a source of protein due to the low Feed Conversion Ratio (FCR) value and high fat absorption efficiency. Maggot meal (Hermetia illucens) is an alternative protein source has been widely studied in poultry feed, containing approximately 40–45% crude protein. This study aimed to evaluate the effect of different levels of maggot meal as an alternative animal protein source on the optimal nutritional content of starter-phase broiler feed. The study used a Completely Randomized Design (CRD) with five treatments and three replications (15 samples), which were analyzed in the laboratory. The treatments included P0 (0%), P1 (5%), P2 (10%), P3 (15%), and P4 (20%) maggot meal. Based on the results of proximate analysis of moisture content, crude protein, crude fat, crude fiber, and ash content, the P4 treatment (20% maggot meal) yielded the best results with an optimal feed nutrient composition that meets the requirements of starter-phase broiler chickens. Further research can be conducted by testing maggot-based feed directly on livestock through in vivo trials.*

***Keywords**: broiler chicken, feed, maggot meal, nutrient content, starter*.

Abstrak*.* Formulasi pakan yang tepat diperlukan untuk memenuhi kebutuhan zat-zat makanan yang diperlukan dalam jumlah cukup untuk mendukung produktivitas ternak. Ayam broiler fase starter memiliki kebutuhan protein kasar tertinggi karena merupakan fase pertumbuhan yang penting dalam pembentukan otot dan jaringan tubuh. Ayam broiler memiliki kemampuan yang baik dalam memanfaatkan nutrisi melalui pakan alternatif sebagai sumber protein karena nilai Feed Conversion Ratio (FCR) yang rendah dan efisiensi penyerapan lemak yang tinggi. Tepung maggot (*Hermetia illucens*) merupakan salah satu bahan pakan alternatif yang banyak diteliti, mengandung protein kasar sekitar 40–45%. Penelitian ini bertujuan untuk mengevaluasi pengaruh penggunaan tepung maggot dengan tingkat yang berbeda sebagai sumber protein hewani terhadap kandungan nutrisi ransum ayam broiler fase starter. Penelitian menggunakan Rancangan Acak Lengkap (RAL) dengan lima perlakuan dan tiga ulangan (15 sampel) yang dianalisis di laboratorium. Perlakuan terdiri dari P0 (0%), P1 (5%), P2 (10%), P3 (15%), dan P4 (20%) tepung maggot. Berdasarkan hasil uji proksimat dari kadar air, protein kasar, lemak kasar, serat kasar, dan kadar abu menunjukkan bahwa perlakuan P4 (20% tepung maggot) memberikan hasil terbaik dengan komposisi nutrisi ransum yang optimal sesuai kebutuhan ayam broiler fase *starter*. Penelitian lanjutan bisa dilakukan dengan menguji pakan maggot langsung pada ternak secara in vivo.

Kata kunci: ayam broiler, fase starter, kandungan nutrisi, ransum, tepung.

INTRODUCTION

The livestock sector plays a significant role in agriculture, particularly in providing animal protein and enhancing public welfare (Ilham et al., 2023). Broiler chicken is one of the leading commodities due to its short production cycle, fast capital turnover, and wide market potential. According to the Central Bureau of Statistics 2021, broiler chicken population in Indonesia increased by 4.59% annually, in line with a 4.3% rise in per capita chicken meat consumption from 2022 to 2023 (National Food Agency). This reflects the high demand for broiler chicken as an affordable, nutritious, and easily accessible source of animal protein (Adji et al., 2021).

The growth performance of broiler chickens is highly influenced by feed quality, especially crude protein, which is essential for tissue formation and metabolism. The Indonesian National Standard (SNI 8173.2:2023) requires a minimum of 18% crude protein in starter-phase broiler feed. Common protein sources such as soybean meal and fish meal present several challenges, including price fluctuations, inconsistent quality, and limited availability (Harahap et al., 2024). Therefore, alternative protein sources that are affordable and sustainable are needed.

Maggot meal (*Hermetia illucens*) is a promising alternative protein source with crude protein content ranging from 40–50% (Trison et al., 2022), and it also contains antimicrobial and antifungal compounds that enhance livestock immunity (Rambet et al. 2015). Maggots are easily cultivated using simple rearing systems and play a crucial role as biological converters of organic waste. In the processing stage, the oven-stove drying method is commonly applied to preserve the nutritional quality of the maggot meal, reduce moisture content, and enhance its aroma (Purnamasari et al., 2021). These processing benefits not only improve feed safety and storage stability but also make maggot meal a promising, sustainable alternative protein source to reduce reliance on conventional fish meal in animal feed formulations.

This study aims to evaluate the effect of different levels of maggot meal inclusion as an alternative animal protein source in starter-phase broiler feed. The observed parameters include moisture content, crude protein, crude fat, crude fiber, ash content, nitrogen-free extract (NFE), and metabolizable energy (ME). The ration was formulated in mash form using main ingredients such as corn, bran, pollard, soybean meal, fish meal, and maggot meal. The results are expected to offer a more efficient, economical, and sustainable feed formulation for the poultry industry.

MATERIALS AND METHODS

Source of Data

The study was conducted in January–February 2025 using experimental feeds for broiler starter chickens, consisting of five treatments with three replications, formulated with varying levels of black soldier fly larvae meal as an alternative protein source. The 16-day-old maggot, reared on tofu dregs, were obtained from the Pelem Women Farmers Group (Kediri, East Java), while feed formulation and processing took place in Tertek Village, Pare District. Feed samples were analyzed at the Nutrition Laboratory of BSIP Ruminansia Besar (Grati, Pasuruan), using standard methods to determine dry matter, crude protein, fat, fiber, ash, nitrogen-free extract, and metabolizable energy. The Table 1 showed the nutritional content of each feed ingredient used:

Table 1. The nutritional content of each feed ingredient used in this study

Ingredients	Dry Material	Crude Protein	Crude Fat	Crude Fiber	Ash	ME	Sources
Ground Corn	90	9	3.5	2	1.5	3400	(Database BSIP.RB)
Rice Brand	88.72	12	8	22.17	9.75	2600	(Database BSIP.RB)
Soybean Meal	88	40.05	4.08	0.47	6	2240	(Database BSIP.RB)
Wheat Pollard	90	17	3	8	7	1600	(Database BSIP.RB)
BSFL Meal	95	45	19.61	5	15	2500	(Rosyadi et al., 2024)
Fish Meal	88	50	5	5.6	20	3000	(SNI 2715-2013)
Vegetable Oil	-	-	99.9	-	-	8000	(SNI 3741:2013)
Premix	90	-	-	-	85	-	(PT. Medion, 2025)

Experimental Design and Treatment

The study was conducted using a Completely Randomized Design (CRD) with five treatments and three replications (n = 15). Table 2, showed the treatments consisted of varying inclusion levels of maggot meal in the feed rations.

Table 2. Summarizes The Treatment Groups, Which Included Different Inclusion Levels Of Maggot Meal Incorporated Into The Chicken Feed Formulations.

Treatments	Ingredients						
	Ground Corn	Rice Brand	Soybean Meal	Wheat Pollard	BSFL Meal	Fish Meal	Vegetable Oil
P0	45%	10%	15%	8,5%	0%	20%	1%
P1	45%	10%	15%	8,5%	5%	15%	1%
P2	45%	10%	15%	8,5%	10%	10%	1%
P3	45%	10%	15%	8,5%	15%	5%	1%
P4	45%	10%	15%	8,5%	20%	0%	1%

All experimental rations were formulated to meet the nutritional requirements of starter-phase broilers and were supplemented with 0.5% Neobro® premix (PT. Medion, Bandung, Indonesia), containing amino acids, vitamins, and minerals.

Maggot Meal Preparation

The larvae were initially washed thoroughly to remove impurities, followed by boiling for 3 minutes in a stainless-steel cooking pot (Jawa, Jakarta) to eliminate potential microorganisms and reduce unpleasant odors. Subsequently, the larvae were dried using a gas oven (Hock, Surabaya) at medium heat for approximately 75 minutes, ensuring complete dehydration (Purnamasari et al., 2021). The dried larvae were then ground using a chopper (Maspion, Surabaya) and sieved with a stainless-steel mesh to obtain a uniform particle size. The resulting maggot meal was stored in airtight plastic containers (Lion Star, Jakarta) to maintain its quality and prevent moisture reabsorption until further use.

Proximate Analysis and Laboratory Procedures

Moisture Content Analysis

Moisture content was determined using the gravimetric method in accordance with AOAC (2019) guidelines. Equipment used included a hot air oven (Memmert UF55, Schwabach, Germany), analytical balance (Ohaus Pioneer PA214, Parsippany, USA), porcelain crucible (Iwaki, Tokyo, Japan), desiccator (Bel-Art, New Jersey, USA), and stainless-steel tongs. Approximately 2 grams of each sample were weighed into a dried and pre-weighed porcelain crucible, then dried at 135°C for 2.5 hours, cooled in a desiccator, and reweighed. The moisture content was calculated using the following formula:

$$\text{Moisture (\%)} = \frac{B - C}{B - A}\ x\ 100\%$$

Explanation:
A = weight of empty crucible (g)
B = weight of crucible + sample before drying (g)
C = weight of crucible + sample after drying (g)

Crude Protein Analysis

Crude protein was determined using the Kjeldahl method in accordance with SNI 7275:2008. The equipment used included an analytical balance, Kjeldahl flask (Pyrex, USA), digestion heater (Heidolph MR Hei-Standard, Germany), distillation apparatus (Markanstill Apparatus, China), Erlenmeyer flask, burette, pipette (Eppendorf, Germany), and desiccator. The reagents employed in the analysis were concentrated sulfuric acid (H_2SO_4), selenium catalyst, 30% sodium hydroxide (NaOH), a mixed indicator solution, 2% boric acid, and 0.01 N hydrochloric acid (HCl). The crude protein content was calculated using the following formula:

$$\text{Crude Protein (\%)} = \frac{(V1 - V2) x\ N\ x\ 14{,}007\ x\ f}{W}$$

Explanation:
W = sample weight (g)
$V1$ = volume of HCl for sample (mL)
$V2$ = volume of HCl for blank (mL)
N = HCl normality
F = conversion factor (6.25)

Crude Fat Analysis

Crude fat content was determined using the Soxhlet extraction method, following the procedures outlined by AOAC (2019). The equipment utilized included a Soxhlet apparatus (Buchi B-811, Switzerland), a hot air oven, an analytical balance, and a round-bottom flask. Petroleum ether served as the extraction solvent. Approximately 1 g of the dried sample was wrapped in an extraction thimble (Whatman No. 1, USA), pre-dried at 105°C, and subjected to continuous extraction for approximately 6 hours. Following extraction, the solvent was evaporated, and the residual fat was weighed. Crude fat content was calculated using the following formula:

$$\text{Crude } Fat \text{ (\%)} = \frac{W2 - W}{W1}\ x\ 100\%$$

Explanation:
W = flask weight (g)
$W1$ = sample weight (g)
$W2$ = flask + fat residue weight (g)

Crude Fiber Analysis

Crude fiber content was determined in accordance with SNI 7275:2008, following fat extraction. The procedure employed a reflux apparatus, filtration vacuum pump (Heidolph, Germany), drying oven, muffle furnace (Carbolite CWF 1200, UK), desiccator, and analytical balance. The reagents used included 1.25% sulfuric acid (H_2SO_4) and 3.25% sodium hydroxide (NaOH). The defatted sample was sequentially digested in acid and alkali solutions, followed by filtration, drying, and incineration at 600°C to remove organic matter. The residue remaining after combustion represented the crude fiber content, which was calculated using the following formula:

$$\text{Crude Fiber (\%)} = \frac{W2 - W3 - W1}{W} \ x \ 100\%$$

Explanation:
W = sample weight (g)
$W1$ = filter paper weight (g)
$W2$ = dried weight (g)
$W3$ = ashed weight (g)

Ash Content Analysis

Ash content was determined using the dry combustion method, following the AOAC (2019) procedures. The equipment used included porcelain crucibles, a hotplate, a drying oven, a muffle furnace (Carbolite, UK), a desiccator, and an analytical balance. Approximately 2 grams of sample were first charred on a hotplate to remove volatile components, then incinerated in a muffle furnace at 600°C for 2.5 hours until white or light grey ash was obtained. The crucibles were subsequently cooled in a desiccator and reweighed. The ash content was calculated using the following formula:

$$\text{Ash Content (\%)} = \frac{W2 - W}{W1} \ x \ 100\%$$

Explanation:
W = crucible weight (g)
$W1$ = sample weight (g)
$W2$ = crucible + ash weight (g)

Nitrogen-Free Extract (NFE)

NFE was calculated using differential method according to Suryaningrum et al. (2017):

$$NFE = 100 - (Moisture + Ash + Protein + Fat + Fiber)$$

Metabolizable Energy (ME)

ME was calculated using the National Research Council (NRC, 1994) formula:

$$ME \ (kcal/kg) = 53 + (Fat \ x \ 38) + (Protein \ x \ 18{,}5) + (NEF \ x \ 8{,}5)$$

The constant 53 serves as a correction value based on baseline digestibility (Widodo et al., 2018).

Statistical Analysis

The collected data were analyzed using one-way Analysis of Variance (ANOVA) with SPSS version 26.0, applying a significance level of 0.05. When significant differences among treatments were observed, the means were further compared using Duncan's Multiple Range Test (DMRT) to determine specific pairwise differences.

RESULTS AND DISCUSSION

The result for proximate analysis of maggot meal are presented in Table 3. The larvae/maggot, reared on tofu dregs and harvested at 16 days old, showed slightly lower protein content compared to those harvested at an earlier stage.

Table 3. The result of proximate analysis of maggot meal

Sample	Moisture 135ºC	Dry Matter	Proximate Analysis Result	
			Crude Protein	Crude Fat
Maggot meal	3,61 %	96,39 %	44,23 %	19,97 %

Azis et al. (2022, as cited in Yandi et al., 2024) reported 14-day-old larvae fed tofu dregs had 45.40% crude protein, while Rachmawati et al. (2010, as cited ini Rosyadi et al., 2024) found 44.01% crude protein and 19.61% crude fat in 15-day-old larvae, indicating that larval age significantly influences nutrient composition. Oven-drying was selected as the processing method to reduce fat levels, as the extended drying time promotes fat oxidation and evaporation. In contrast, microwave-drying tends to retain more fat due to its shorter exposure time (Purnamasari et al., 2024). Consequently, oven-dried BSFL exhibited lower fat content than microwave-dried larvae, as also observed by Intan et al. (2023).

The result of proximate composition of chicken feed rations with varying levels of maggot meal (% dry matter basis) are presented in Table 4. Different levels of maggot meal significantly affected (P<0.05) the moisture, crude protein, crude fat, crude fiber, and ash content of broiler starter feed. The moisture content of diets decreased as the inclusion level of maggot meal increased. Treatments P0 and P1 had the highest moisture levels, followed by P2, while P3 and P4 had the lowest

Table 4. Proximate Composition of Chicken Feed Rations with Varying Levels of Maggot Meal (% Dry Matter Basis)

Treatments	BSF Meal (%)	Mean ± Standard Deviation				
		Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Ash (%)
P0	0%	11.31±0.04^{a}	13.58±2.71^{a}	4.85±0.72^{a}	8.82±0.76^{d}	7.87±0.72^{a}
P1	5%	11.32±0.30^{a}	17.34±0.51^{b}	5.70±0.41^{b}	8.02±1.35^{cd}	7.30±0.08^{b}
P2	10%	10.75±0.27^{b}	20.64±0.84^{c}	6.67±0.19^{c}	7.27±0.30^{bc}	7.13±0.03^{c}
P3	15%	10.25±0.18^{c}	21.07±0.17^{c}	7.21±0.23^{cd}	6.21±0.38^{ab}	6.40±0.11^{d}
P4	20%	10.27±0.02^{c}	19.60±0.63^{bc}	7.75±0.20^{d}	5.59±0.53^{a}	6.11±0.08^{e}

Explanation: Different superscripts in the same row indicate significant differences (P<0.05)

The decrease in moisture content from P0 to P4 corresponds to the higher proportion of maggot meal, which contains only 3.61% moisture (Feed Nutrition Laboratory, BSIP Pasuruan, 2025), compared to fish meal (6–12%) (SNI 01-2715-1996). All treatments met the broiler starter standard of ≤13% moisture (SNI 8173-2:2023). Controlling feed moisture is crucial, as high levels promote mold growth, while low levels may reduce palatability and cause dusty feed. Thus, proper formulation and storage are essential (Nurillah, Ahda, and Erlita 2023).

The highest protein levels in P2 and P3, while P0 had the lowest. Treatment P4 showed higher protein than P0 and P1, but lower than P2 and P3. The increase in crude protein from P1 to P3 was influenced by the high protein content of maggot meal (44.23%) (Feed Nutrition Laboratory, BSIP Pasuruan, 2025). P0 had the lowest value due to the absence of maggot meal. Although fish meal generally has a higher protein content (45–75%) depending on quality (SNI 01-2715-1996), lower-quality fish meal contains only 44% (Bidayani et al. 2023), and soybean meal has 40.05% (Rasmi et al., 2020). The decline in P4 was likely due to the removal of fish meal, a high-quality protein source. Despite fish meal's higher protein content, studies by Kroeckel et al. (2012) and (Mangisah et al., 2022) suggest that maggot meal combined with soybean meal can yield comparable or better results. Treatments P2, P3, and P4 met the broiler starter standard of ≥18% protein (SNI 8173-2:2023). Ilham et al., 2023 also reported that 10–15% maggot meal increased protein content, feed intake, and body weight gain. Teguia et al. (2002 as cited in Rambet et al., 2015) found similar results when replacing fish meal with maggot meal. The protein drop in P4 compared to P2 and P3 may also be linked to nutrient imbalance and high fat content, which can dilute protein and interfere with digestive enzymes(Azizah et al., 2017). Reduced ash content may also impact nutrient stability, including crude protein. While maggot meal is a promising alternative protein source, careful formulation is needed to maintain feed quality and broiler performance.

The crude fat of diets increased as the inclusion level of maggot meal increased. P4 had the highest fat content, while P0 had the lowest. The increase from P0 to P4 followed the higher inclusion of maggot meal, which contains 19.97% fat (LPSI-RB Pasuruan, 2025). This trend aligns with Widjastuti et al., (2016 as cited in Rumondor et al., 2015) who found that maggot meal increases fat content more than fish meal. All treatments met the minimum 4% crude fat requirement (SNI 8173-2:2023). Although high in fat, maggot meal also provides lauric acid with antimicrobial and immune-boosting benefits (Putra et al., 2022). Proper fat levels are essential for energy and growth, but excess fat may reduce digestibility (Syukri, Yenrina, and Azima 2020), so maggot meal use must be balanced.

The crude fiber of diets decreased as the inclusion level of maggot meal increased. P4 had the lowest fiber content, while P0 had the highest (DMRT test). A decreasing trend from P0 to P4 followed the higher inclusion of maggot meal, which contains less fiber (5%) than fish meal (5.6–10.1%) (Rosyadi et al., 2024; SNI 01-2715-1996; Sihite 2013). Although neither ingredient is a primary fiber source, their fiber content differences may have influenced overall levels. All treatments slightly exceeded the maximum 5% standard for broiler starter feed (SNI 8173-2:2023), but P4 remained close to the limit. High fiber levels were mainly due to rice bran (22.17%) and pollard (8%) (Azizah et al. 2017); Rosani et al., 2023). Crude fiber supports digestive health, prevents constipation, and promotes satiety (Korompot et al., 2018), making its balance important for broiler performance.

The ash content of diets increased as the inclusion level of maggot meal increased. P0 had the highest ash content, while P4 had the lowest (DMRT test). The decrease from P0 to P4 followed the increasing use of maggot meal, which contains less ash (15%) compared to fish meal (20%) (Rosyadi et al., 2024; SNI 01-2715-1996). Despite the decrease, all treatments remained within the acceptable range of ≤9% (SNI 8173-2:2023). Ash reflects the mineral content in feed, including calcium, phosphorus, magnesium, and potassium—vital for bone growth and metabolism. Although maggot meal has slightly lower mineral levels, it can still meet broiler requirements and has been shown to support calcium digestibility (Persik et al., 2016). This is supported by Kusrini et al. (2021), who found comparable ash levels between maggot and fish meals.

The result of Nitrogen-Free Extract (NFE) and Metabolizable Energy (ME) of chicken feed rations with different levels of maggot meal are presented in Table 5. The inclusion levels of maggot meal had no significant effect (P>0.05) on the nitrogen-free extract (NFE) content.

Table 5. Nitrogen-Free Extract (NFE) and Metabolizable Energy (ME) of Chicken Feed Rations with Different Levels of Maggot Meal

Treatments	BSF Meal (%)	Mean ± Standard Deviation	
		NFE (%)	ME (kcal/kg)
P0	0%	53.56±2.62	943.79±55.04^{a}
P1	5%	50.31±1.99	1018.02±13.62^{b}
P2	10%	48.03±2.49	1096.54±13.25^{c}
P3	15%	51.25±2.45	1142.45±21.80^{d}
P4	20%	51.01±1.08	1143.68±10.91^{cd}

Explanation: Different superscripts in the same row indicate significant differences (P<0.05)

Although the Indonesian National Standard (SNI 8173.2:2015) does not specify a minimum requirement for NFE, this fraction, comprising primarily starches and simple sugars plays a critical role in meeting the energy demands of broiler chickens, particularly during early growth and metabolic development (Prawirodigdo et al., 2019). When compared to commercial starter feeds such as CP 511, which typically contain 60–75% NFE, the experimental formulations in this study exhibited relatively lower NFE levels.

Different levels of maggot meal significantly affected (*P*<0.05) the metabolizable energy (ME) of broiler starter diets. Treatment P3 had the highest ME, while P0 had the lowest. This increase was likely due to the higher crude fat content in maggot meal (19.97%) compared to fish meal (8–12%), as fat is a dense energy source. However, all treatments still had ME values below the ideal standard of 2800 kcal/kg for broiler starters (SNI 8173-2:2023). Low ME can reduce growth rate, worsen feed conversion, and lead to poor protein use (Zanu et al., 2012; Onyango et al., 2019). Although the metabolizable energy (ME) values remained below the established standard, the observed upward trend with increasing maggot meal inclusion indicates its potential as an alternative energy source, particularly if supported by improved formulation strategies.

CONCLUSION

The incorporation of maggot meal into broiler starter diets significantly influenced several nutritional parameters, including moisture, crude protein, crude fat, crude fiber, ash content, and metabolizable energy, while it had no significant effect on nitrogen-free extract (NFE). Among the treatments, the inclusion level of 20% maggot meal (P4) produced the most optimal results, yielding 19.60% crude protein and 7.75% crude fat, both essential for supporting growth performance and metabolic functions in broiler starter chickens. Additionally, the crude fiber content was reduced to 5.59%, which may contribute positively to digestive health. Although the observed metabolizable energy remained slightly below the national SNI standard of 2800 kcal/kg, the increasing trend associated with higher maggot meal inclusion levels suggests its potential as a viable alternative energy source. Based on these findings, maggot meal can be considered a partial substitute for fish meal in poultry feed, with an optimal inclusion level identified at 20%.

REFERENCES

Adji, D., Susanty, A., & Tafsin, M. (2021). Analisis kualitas daging ayam broiler asal pasar swalayan dan pasar tradisional di Kota Medan, Sumatera Utara. *Jurnal Sain Veteriner*, 39(3), 224–232. https://doi.org/10.22146/jsv.54354

AOAC. (2019). Official methods of analysis of AOAC International (21st ed.). AOAC International

Azizah, N. A., L. D. Mahfudz, and Dan D. Sunarti. 2017. Kadar lemak dan protein karkas ayam broiler akibat penggunaan tepung limbah wortel (Daucus Carota L.) dalam ransum fat and protein contents of carcass broiler due to the use of waste carrot meal in the diet. *Jurnal Sain Peternakan Indonesia* 12(4):389.

Badan Pangan Nasional. (2023). *Laporan konsumsi pangan nasional 2023* [National food consumption report 2023]. Badan Pangan Nasional. Retrieved July 21, 2025, from https://www.bapanas.go.id

Badan Pusat Statistik. (2021). *Statistik peternakan dan perikanan 2021* [Livestock and fisheries statistics 2021]. Badan Pusat Statistik. Retrieved July 21, 2025, from https://www.bps.go.id

Badan Standardisasi Nasional. (2008). *SNI 7275:2008 – Cara uji kadar protein dan serat kasar dalam pakan ternak* [SNI 7275:2008 – Method for testing protein and crude fiber levels in animal feed]. Badan Standardisasi Nasional. Retrieved July 21, 2025, from https://www.bsn.go.id

Badan Standardisasi Nasional. (2006). *SNI 01-3931-2006: Bahan baku pakan ternak* [Feed ingredients]. Badan Standardisasi Nasional. Retrieved July 21, 2025, from https://www.bsn.go.id

Badan Standardisasi Nasional. (2023). *SNI 8173.2:2023 – Pakan ayam: Bagian 2 – Pakan ayam broiler* [Chicken feed: Part 2 – Broiler feed]. Badan Standardisasi Nasional. Retrieved July 21, 2025, from https://www.bsn.go.id

Bidayani, E,. Puspa, T., Fitri A., and Valen, S. (2023). Pembuatan pakan alternatif (berbentuk pasta) berbahan dasar limbah tepung ikan rucah di desa batu belubang kabupaten bangka tengah [The alternative feed production (paste-form) with trash fish meal waste in Batu Belubang , Central Bangka. *Jurnal Pengabdian Kepada Masyarakat*, 3(1), 122–130

Harahap, H., Manurung, R., Nasution, H., Masyithah, Z., & Yustira, A. (2024). Proses pengolahan pakan unggas dari tepung ikan di desa sentang kecamatan teluk mengkudu kabupaten serdang bedagai. *Jurnal Abdimas Madani Dan Lestari (JAMALI)* 06(September):168–75. doi: 10.20885/jamali.vol6.iss2.art10.

Ilham, I., B. Putra, and A. Aswana. 2023. Pengaruh penggantian sebagian ransum komersil dengan

tepung maggot (*Hermetia illucens*) terhadap pertumbuhan ayam broiler (Gallus Dommesticus). *Stock Peternakan* 5(2):102–8.
Korompot, A. R. H., Fatimah, F., & Wuntu, A. D. (2018). Kandungan serat kasar dari bakasang ikan tuna (Thunnus Sp.) pada berbagai kadar garam, suhu dan waktu fermentasi. *Jurnal Ilmiah Sains* 18(1):31. doi: 10.35799/jis.18.1.2018.19455.
Mangisah, I., Mulyono, & Yunianto, V. D. (2022). Maggot bahan pakan sumber protein untuk unggas.
Nurillah, Y. A., & Erlita, Y. (2023). Uji kadar air pakan ternak daerah sijunjung dengan metode gravimetri. *Prosiding SEMNAS BIO* 1241–46.
National Research Council. (1994). *Nutrient requirements of poultry* (9th rev. ed.). National Academies Press.
Onyango, A. A., Dickhoefer, U., Rufino, M. C., Butterbach-Bahl, K., & Goopy, J. P. (2019). Temporal and spatial variability in the nutritive value of pasture vegetation and supplement feedstuffs for domestic ruminants in Western Kenya. *Asian-Australasian Journal of Animal Sciences*, *32*(5), 637–647
Purnamasari L., Widyaningrum D.C., Muhlison W., Krismaputri M.E., Sucipto I., Pratiwi N. 2021. Amino Acid Profile and Proximate Composition of Black Soldier Fly Larvae (*Hermetia illucens*) with two drying methods. 177–184.
Rambet, V., Umboh, J. F., Tulung, Y. L. R., & Kowel, Y. H. S. (2015). Kecernaan protein dan energi ransum broiler yang menggunakan tepung maggot (*Hermetia illucens*) sebagai pengganti tepung ikan. *Zootec* 35(2):13. doi: 10.35792/zot.36.1.2016.9314.
Rosyadi, M. A., Purnamasari, D. K., Erwan, Sumiati, Wiryawan, K. G., Syamsuhaidi, & Maslami, V. (2024). Komposisi nutrisi maggot yang dibudidaya pada media berbasis limbah telur infertil dan ampas tahu. *Jurnal Sains Teknologi & Lingkungan* 10(1):118–28. doi: 10.29303/jstl.v10i1.572.
Rumondor, G., Maaruf, K., Tulung, Y. R. L., & Wolayan, F. R. (2015). Pengaruh penggantian tepung ikan dengan tepung maggot black soldier (*Hermetia illucens*) dalam ransum terhadap persentase karkas dan lemak abdomen broiler. *Zootec* 35(2):131. doi: 10.35792/zot.36.1.2016.10452.
Sihite, H; H. 2013. "Studi pemanfaatan limbah ikan dari tempat pelelangan ikan (tpi) dan pasar tradisional nauli sibolga menjadi tepung ikan sebagai bahan baku pakan ternak." *Jurnal Teknologi Kimia Unimal* 2(2):43–54.
Syukri, D., Yenrina, R., & Azima, F. (2020). Serba serbi praktis analisis proksimat bahan pangan *bagi mahasiswa*.
Trison, B. N., Datta, F. U., & Nitbani, H. (2022) Uji performa pertumbuhan dan profil sel darah merah ayam broiler (fase starter) yang diberi pakan tepung magot bsf (black soldier fly) sebagai pakan tambahan pada ransum komersial. *Jurnal Veteriner Nusantara* 5(2):113–24. doi: 10.35508/jvn.v5i2.8611.
Yandi, H., L. Maianti, and S. Suliasih. 2024. Penambahan level tepung maggot black soldier fly (*Hermetia illucens*) didalam ransum terhadap performan ayam joper.4(2):50–58.
Zanu, H. K., Asiedu, P., Tampuori, M., Abada, M., & Asante, I. (2012). Possibilities of using *Moringa oleifera* leaf meal as a partial substitute for fishmeal in broiler chicken diets. *Online Journal of Animal Feed Research*, *2*(1), 70–75. Retrieved July 31, 2025, from http://www.ojafr.ir/main/index.php?option=com_content&view=article&id=82