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PERFORMANCE AND FEED DIGESTIBILITY OF SENTUL CHICKEN FED HYDROLYZED MAGGOT (*Hermetia illucens*) MEAL PRODUCED BY CRUDE ENZYMES FROM TEMPEH YEAST

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ABSTRACT

Maggot is the larva of the *Black Soldier Fly* (BSF) which has the potential as an alternative protein source for poultry. The study aimed to examine the supplementation of hydrolyzed and non-hydrolyzed maggot meals to increase the performance and feed digestibility of Sentul chicken feed. Crude enzymes produced from Tempeh yeast were used as inoculum starters. The research method used was a completely randomized design (CRD) with 7 treatments and 3 replications, each replication consisted of five Sentul chickens of four weeks old. The treatments were R_0 = basal feed (control), R_1 = R_0 + 2% non-hydrolyzed maggot, R_2 = R_0 + 4% non-hydrolyzed maggot, R_3 = R_0 + 6% non-hydrolyzed maggot, R_4 = R_0 + 2% hydrolyzed maggot, R_5 = R_0 + 4% hydrolyzed maggot, R_6 = R_0 + 6% hydrolyzed maggot. Variables observed were feed intake (FI), total weight (TW), weight gain (WG), feed conversion ratio (FCR), crude protein digestibility (CPD), and crude fiber digestibility (CFD). The data were analyzed utilizing Analysis of Variance (ANOVA) and Tukey's honestly significance difference (HSD) test was also conducted. The results demonstrated that the addition of maggot meal had a significant impact ($P<0.01$) on the variables TW, WG, FCR, and CPD, and a moderately significant impact ($P<0.05$) on FI and CFD. When supplemented with 4% and 6% non-hydrolyzed maggot meal, FI and CFD were raised. However, when supplemented with the same percentage of hydrolyzed maggot meal, there was a significant increase in WG and TW while also decreasing the FCR value. Incorporation of 4% hydrolyzed (R_5) maggot meal optimized WG, TW and FCR values, and boosted the CPD coefficient from 82.16 ± 1.46 (R_0) to 93.14 ± 0.15 and CFD from 60.01 ± 2.40 (R0) to 83.90 ± 0.40 (R_6) at the 6% level. In conclusion, the supplementation of hydrolyzed maggot (*Hermetia illucens*) meal, with crude enzymes from Tempeh yeast, significantly enhanced the performance and feed digestibility of Sentul chicken diets. Supplementation of 4 and 6% gave relatively the same performance, but the best digestibility was found in addition of 6%.

Key words: enzymes, digestibility, larvae, performance, sentul-chicken, tempeh, supplementation, hydrolysis

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INTRODUCTION

Sentul chicken, originating from Ciamis district, is a native Indonesian breed that has the potential to be developed as both meat and egg producing chicken due to its advantageous traits such as fast growth and high egg production when compared to other local chicken species. The average body weight of Sentul chickens is 1.6 kg at the age of 20 weeks under intensive maintenance and they are generally slaughtered at the age of 8-12 weeks when the weight reaches 750 g [1]. Sentul egg production reaches 120-140 eggs per year [2]. Increasing the productivity of native chickens so far is through improving rearing management and feed quality, especially under intensive maintenance.

Maggot meal is an alternative feed that can be used to improve the quality of poultry diets. The maggot is a larva of the *Black Soldier Fly* (BSF) that can thrive in tropical climates and can reduce organic waste. Maggot is easy and cheap to cultivate because it has a short life time and it can grow in organic waste media. The protein and fat levels in maggots vary based on their rearing environment. For instance, when larvae are raised in a mixture of coconut endosperm waste and soybean curd residue (in a 1:1 ratio by weight), the protein content can reach as high as 48.6%, while the lipid content is lower at 9.61%. On the other hand, when larvae are reared solely in coconut endosperm waste and soybean curd residue, the maggot protein content remains similar, ranging from 37.20% to 40.36%, and the fat content varies between 9.61% and 20.02% [3]. Maggots have high biological value, hence, they are a suitable protein source for poultry feed. Maggot can be used as fresh or in meal form, typically used as a substitute for soybean or fishmeal in poultry diets. Approximately 4.1% of farmers in the western region of Burkina Faso use maggot regularly and 10.8% occasionally as a feed supplement for poultry [4]. In broiler and laying hens, maggot meal has been used as an alternative to soybean or fish meal [5, 6].

Another advantage of maggot is the bioactive content that can improve the health of chickens. Maggot also has a relatively high lauric acid content of 49.18%, it is a medium chain fatty acids (MCFA) that has antimicrobial activity. Adding of 0.1-1.4% MCFA in feed reduced colonization of pathogens in the gut [7]. Supplementation of 5% palm kernel fatty acids containing 42–53% of lauric acid in broiler diets reduced the population of Campylobacter coli in broiler breast [12]. Nevertheless, the utilization of maggot meal is limited due to its high chitin content, which requires processing to reduce the levels of chitin. Maggot typically contains 7.0-8.74% chitin in dry matter [8]. Chitin is a water-insoluble polymer made up of β-1,4-linked N-acetylglucosamine (GlcNAc) and is a primary component of insect

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cuticles [9]. The inclusion of maggot meal in broiler feed at levels exceeding 15% can decrease weight gain [10]. Khempaka *et al.* [11] informed that substitution of soybean meal by 15% shrimp meal in broiler feed (2.8% chitin equivalent) did not affect growth performance and feed digestibility, however, above this level it had negative impact on growth, FCR and digestibility.

Chitin is a polymer that is difficult to dissolve and digest by poultry because poultry does not have chitinase in the digestive tracts, so the presence of chitin in feedstuffs inhibits digestion and nutrient absorption. Chitin is composed of monomer chains of N-acetyl glucosamine and chitinase cleaves the inter-linkage N-acetyl glucosamine. An option to reduce chitin and increase maggot digestibility is through degradation using microorganisms or extracellular enzymes, such as Tempeh yeast. Tempeh yeast is a cell culture that is used for fermenting soybean in the process of producing tempeh. Tempeh, is a traditional Indonesian food product that is highly preferred and highly nutritious. Tempeh yeast contains micro-organisms, especially mold, viz. *Rhizopus oligosporus*, *R. oryzae, R. arrhizus, R. stolonifer* or *Mucor javanicus* [19]. *Rhizopus oryzae* was reported to produce various types of enzymes like amylase, protease, lipase, cellulase, hemicellulase, pectinase, tannase, phytase [12] and chitinase [13].

Hydrolysis of maggot by enzymes will reduce chitin content, increasing the availability of bioactive peptides and short chain fatty acids. Maggot hydrolysis produces maggot meal with high digestibility and antimicrobial compounds. Tempe yeast is a commercial product that can be purchased conveniently and inexpensively by farmers in villages. Fermentation technology has been widely applied in villages to make traditional food that is soybean tempeh. Production of crude extracts using Tempeh yeast through simple fermentation technology allows the application of crude enzymes for maggot hydrolysis at the farmer level. In this study, maggot was hydrolyzed using crude enzymes from Tempeh yeast, this process increased nutrient availability and reduced chitin which increased maggot meal digestibility and performance of Sentul chicken. This study aimed to evaluate the effects of hydrolyzed maggot meal addition on performance and digestibility of Sentul chicken feed.

MATERIALS AND METHODS

Birds and Diets. This study was performed in accordance with the regulations of University of Jenderal Soedirman no. 1499/UN23/PT.01.02/2022. A total of 105 unsexed Sentul chickens of four weeks old were randomly divided into 21 pens. The experimental design used was a completely randomized design (CRD) with seven treatments and three replications. Each replication unit contains five Sentul chickens. The treatments tested were as follows:

1. R_0 : Basal Feed (control)
2. R_1 : R_0 + 2 % nonhydrolyzed maggot meal
3. R_2 : R_0 + 4 % nonhydrolyzed maggot meal
4. R_3 : R_0 + 6 % nonhydrolyzed maggot meal
5. R_4 : R_0 + 2 % hydrolyzed maggot meal
6. R_5 : R_0 + 4 % hydrolyzed maggot meal
7. R_6 : R_0 + 6 % hydrolyzed maggot meal

All data were expressed as means ± standard deviation. The data were analyzed using Statistical Package for Social Sciences (SPSS) series 16 software in a completely randomized design for variance analysis, the means were compared by Tukey's honestly significance difference (HSD).

Crude enzymes production. One hundred grams (100 g) of soybean were boiled in 400 ml of water for 30 minutes in the past to produce crude enzymes. After cooling, 0.2% (g/g soybean) Tempeh yeast was added and the solution was incubated at room temperature for 3x24 h. The resulting solution was filtered to obtain the supernatant which was then centrifuged at 3500 g for 15 min. To the supernatant, 0.05 M phosphate buffer pH 7.00 (3:1) and 50% saturation of ammonium sulfate were added and stirred slowly at a cold temperature. The solution was then stored overnight in a cold room. After centrifugation at 10,000 g for 30 min, pellet enzymes were obtained. These enzymes were dissolved in 0.05 M phosphate buffer pH 7.00 to determine the activity of protease [14] and chitinase [15] for the production of hydrolyzed maggot meal.

Production of non-hydrolyzed and hydrolyzed maggot meal. From the Maggot cultivated from rejected milk media and restaurant waste, the larvae were harvested at 10-15 days of age. The harvested maggots were cleaned using running water and soaked in hot water for 5 minutes. The maggots were dried in an oven at 60^0C for 48 h, then ground into a nonhydrolyzed maggot meal. The cleaned and killed Maggots were mashed using a blender and distilled water (3:1) was added, then mixed 1% (w/v) crude enzymes was also added into the homogenate maggots. Homogenate maggots were incubated at 50^0 C for 24 h, after incubation, the maggots were dried in an oven at 60^0 C for 48 h. The dried homogenate maggots were ground into a hydrolyzed maggot meal.

Feeding trial. The study was conducted with Sentul chickens that were five weeks old at the start of the 28-d treatment period. The feeding trial was divided into two phases: an adaptation phase lasting seven days, followed by a 28-d feeding trial. To determine the average total weight (TW), weight gain (WG), feed intake (FI), and feed conversion ratio (FCR), the collective live weight and residual feed weight of each pen were measured. These measurements were used to calculate the TW, WG, FI, and FCR of the Sentul chickens. Calculations of the variables is as follows:

TW = final body weight (g/b)
WG = final body weight (g/b) – initial body weight (g/b)
FI = [(total feed given (g) × dry matter feed (%)]– [(total residual feed (g) × dry matter residual feed (%)]
FC = total FI (g): total WG (g)

Determination of Digestibility. Excreta collection was carried out for seven days at the end of the experiment using the total collection method. Excreta were collected by attaching trays at the bottom of the cages. Before feeding in the morning, both the excreta and residual feed were collected and weighed, with up to 10% taken as samples. The samples were then dried using an oven at 60°C for 48 h and composited for analysis of the dry matter, protein and crude fiber [16]. Crude protein was measured as total nitrogen by the Kjeldahl flask (AOAC 954.0) and crude fiber was analysed by the Weende method (AOAC 978.10).

Digestibility coefficient of nutrient (crude protein and crude fiber) was measured as described by Wolynetz and Sibbald [17], as follows:

$$\text{Nutrients digestibility (\%)} = \frac{[(\%\text{ nutrient in feed x FI}) - (\%\text{ nutrient in faeces x TF})] \text{ X } 100}{(\%\text{ nutrient in feed x FI})}$$

FI = feed intake (%DM), TF = total faeces (%DM)

RESULTS AND DISCUSSION

Hydrolyzed maggot meal supplementation in Sentul chicken feed had a significant effect (P<0.05) on FI and a very significant effect (P<0.01) on WG, TW and FCR (Table 4). The lowest FI was found in R_0 1613.38 g while the highest FI was found in R_3 1817.03 g. Some researchers reported that feed intake for Sentul chickens at 1-8 weeks was 1800-2200 g/b [2, 18]. In this study R_0 feed intake was relatively

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lower than other experiments. This difference is caused by differences in the nutrient content of the feed.

Furthermore, the addition of 4 and 6% nonhydrolyzed maggot resulted in an increased feed intake of chicken groups of R_2 and R_3. However, the R_1 (2% nonhydrolyzed) FI was relatively the same as R_4, R_5, R_6 (hydrolyzed maggot meal). Maggot supplementation increased protein feed from 17.94% (control) to 20% and crude fiber from 9.07% (control) to 13.82% (R_3) and 13.17% (R_6). Energy metabolism between feed treatments were relatively equal viz. 3400-3500 kcal/kg (Table 2). The quality of feed protein and crude fiber have a significant impact on feed consumption. Non-hydrolyzed maggot meal was found to increase FI, especially when the maggot level was high. However, the use of hydrolyzed maggot meal resulted in similar FI values, even at levels between 2 and 6%. The high chitin content in non-hydrolyzed maggot meal made it difficult to digest as chitin fiber is insoluble [19]. Consequently, the addition of non-hydrolyzed maggot meal raised the crude fiber of the feed (Table 2). Chitin polymer increased the rate of intestine digestion passage and resulted in faster stomach emptying. High fiber levels in feed led to quicker removal from the digestive tract, resulting in faster emptying of the digestive tract and increased feed intake by chickens [20]. Higher levels of chitin caused bulky rations and reduced nutrient intake. As a result, chickens tried to fulfill nutrient requirements by increasing the feed intake.

The addition of hydrolyzed maggot meal 2, 4 and 6% to diets did not interfere with the FI, this indicated that the hydrolysis process by crude enzymes from Tempeh yeast reduced chitin and improved the availability of nutrients. Chitinase activity of Tempeh yeast was 4.01 U/mg (Table 3), this activity is almost equal to thermostable chitinase of *Bacillus* sp. K29-14 that was 4.8 U/mg [15]. Crude extracts Tempeh yeast consist of hydrolytic enzymes such as amylase, protease, lipase, cellulase, hemicellulase, pectinase, tannase, phytase and chitinase [13]. These enzymes degraded polymeric nutrients into simpler molecules so that feed treatments (R_4, R_5, R_6) were easier to digest and absorb.

Hidayat *et al.* [18] and Asmara *et al.* [2] reported that FCR for Sentul chickens fed control feed from 1-10 weeks of age was 3.90-4.21. This study found that the FCR for Sentul chickens fed from 8-16 weeks of age ranged from 2.61-4.82, with the lowest value at R_6 (6% hydrolyzed maggot meal) and the highest at R_2 (4% non-hydrolyzed). The FCR for chickens given non-hydrolyzed maggot meal supplementation was significantly higher than those given hydrolyzed maggot meal (Table 4). Increasing the level of hydrolyzed maggot improved feed protein, decreased FCR values and increased feed efficiency. The FCR for R_5 (4%

hydrolyzed maggot meal) was relatively equal to R6 (6% hydrolyzed maggot meal), and significantly lower than R_1 (2% non-hydrolyzed) and R_2 (4% non-hydrolyzed). Tempeh yeast crude extracts contained chitinase and protease with activity levels of 4.01 U/mg and 10.42 U/mg, respectively (Table 3). Both enzymes reduced maggot chitin and increased the availability of amino acids for meat synthesis. Chickens consuming hydrolyzed maggot meal had similar feed intake but higher weight gain than those given non-hydrolyzed maggot meal. Weight gain improved with increasing levels of hydrolyzed maggot meal (Table 4). The protein content of the R_4, R_5 and R_6 treatments increased due to the use of hydrolyzed maggot meal (Table 2). Protein and amino acid content in poultry feed plays a crucial physiological role in protein synthesis, affecting breast meat yield, FCR and growth to achieve body weight [21].

The use of hydrolyzed maggot meal caused increase in WG and TW, WG and TW values of R_5 and R_6 were relatively similar, but the largest WG and TW were found in R_6 and the lowest in R_0. Weight gain and total weight of chickens in the R_0 (control) treatment were relatively the same as WG and TW in R_1 (2% non-hydrolyzed) and R_2 (4% non-hydrolyzed). Whereas the addition of 6% non-hydrolyzed maggot meal (R_3) resulted in WG and TW that were closed to R_4 (2% hydrolyzed maggot meal). Maggot is a larvae that is rich in protein and fat, the levels of both vary depending on the growing medium. Maggot protein and fat contents are reported as 35-57% and 15-49% respectively, it contains complete essential amino acids, but methionine is in low quantities, while glutamic acid is the largest component of maggot protein [22]. Lauric acid, palmitic acid and myristic acid are the main components of fat maggot and are found in high quantities [3]. Hydrolysis of Lauric acid produces monolaurin which has antimicrobial properties, lauric acid (C12:0) has greatest potential to inhibit the growth of Gram-positive bacteria [23].

Supplementation with maggot meal increased the supply of protein for growth and meat synthesis. The addition of every 2% maggot meal resulted in an improvement of 0.7-1.0% in feed protein content (Table 2). In this study, WG Sentul chickens had a range of 367.15-610.05 g/b and TW ranged from 407.15-650.05 g/b. Total weight of Sentul chickens at 8 weeks of age was 560-620 g/b, while WG was between 436-560 g/b [18, 24]. The WG and TW of the hydrolyzed chicken group were higher than those of the non-hydrolyzed group (Table 4). This indicates that the crude enzymes of Tempeh yeast are capable of degrading maggot protein into peptides and amino acids, thereby increasing the availability of amino acids required for growth and meat synthesis. Amino acids from BSF maggots increase muscle growth and tend to improve weight gain [25]. Moreover, the protease

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activity of crude enzymes degrades protein to produce antimicrobial peptides, while lipase hydrolyzes fat to produce lauric acid and monolaurin. The activity of these two enzymes improves the immune system and performance of chickens.

The supplementation of maggot meal had a significant effect on both CPD ($P<0.01$) and CFD ($P<0.05$). The CFD of the treated feeds ranged from 82.16% (R_0) to 93.14% (R6), while CPD ranged from 60.01% (R_0) to 83.90% (R_6) (Table 5). An increase in maggot supplementation resulted in an increase in both CPD and CFD. The addition of 2% non-hydrolyzed maggot (R_1) produced a higher CFD than the control (R_0), but only supplementation of 4% and 6% were able to improve it. The use of 2% hydrolyzed maggot (R_4) was found to be relatively equal to R_2 and R3. The digestibility of protein is influenced by various factors, including feed protein content, protein absorption in the intestine, feed intake and technological treatments [26].

The use of unprocessed maggot meal in chicken feed were reported resulting to CPD 72,67 ± 1,11% [10] and 56,24– 3,32% [27]. The results of this study have a higher CPD 83,71-88,12% (R_1, R_2, R_3) compared to previous researchers, this was due to the differences in feed composition and feed materials, which determine the quality of the feed. Maggot protein is primarily in a soluble form and is readily digestible. Therefore, the inclusion of maggot meal led to an enhancement in the Crude Protein Digestibility (CPD) coefficient for both non-hydrolyzed and hydrolyzed maggot meal. Notably, the addition of maggot meal had a significant impact, particularly at the 4% and 6% supplementation levels (refer to Table 5).. In addition, lauric acid maggot plays an important role in the development of the digestive tract as a nutrient absorption space [28].

The average Crude Fiber Digestibility (CFD) coefficient in this study falls within the range of 60% to 84%, as shown in Table 5. These findings demonstrate significantly higher CFD values compared to the results reported by Auza [29], who observed CFD values ranging from 15.95% to 49.62% in native chickens when supplemented with 15% maggot meal. . Atchade *et al.* [26] reported that the average CFD of broiler rations in Africa was 22-76%. In this study, the CFD values were different from those of other researchers, this was mainly due to the use of different diets. The basal feed of this study (R_0) was sufficient for native chickens (Table 2). Addition of 4 and 6% non-hydrolyzed and hydrolyzed maggot meal significantly raised CFD coefficient, even though the increase in hydrolyzed was greater than in non-hydrolyzed (Table 5). Supplementation of 2% non-hydrolyzed maggot meal escalates the crude fiber of feed as high as 2.28% when compared to basal feed, while the use of 2% hydrolyzed maggot meal causes an increase in the

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amount by 0.8% (Table 2). Although the levels of chitin in non-hydrolyzed maggot raised with increasing levels of maggot, this condition had an impact on increasing FI which in turn increased the CFD coefficient. The values of CPD and CFD positively correlated with WG and TW. Chickens which received hydrolyzed maggot meal had a higher average of WG and TW compared to those that received non-hydrolyzed maggot meal. This indicates that hydrolyzed maggot provides a variety of nutrients that are available and easily used by chickens for growth and meat production.

The utilization of 4% hydrolyzed (R_5) maggot optimizes the values of WG, TW and FCR, while increasing its boost coefficient CPD from 82.16 ± 1.46 (R_0) to 93.14 ± 0.15 (R_6) and CFD from 60.01 ± 2.40 (R_0) to 83.90 ± 0.40 (R_6) at a 6% level. Adding hydrolyzed maggot meal at 6% provides the highest CPD and CFD coefficients compared to other treatments. Supplementation of Maggot (*Hermetia illucens*) meal which is hydrolyzed by crude enzymes from Tempeh yeast improves the performance and feed digestibility of Sentul chicken diets. The addition of 4 and 6% hydrolyzed maggot meal to Sentul chicken rations generated the same performance but at 6%, it resulted in the highest digestibility of protein and crude fiber.

CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

The supplementation of hydrolyzed maggot meal in Sentul chicken diets has a significant impact on chicken performance. Specifically, at supplementation levels of 4% and 6%, hydrolyzed maggot meal enhances weight gain (WG), total weight (TW), and reduces the feed conversion ratio (FCR). This improvement can be attributed to the increased availability of nutrients derived from hydrolyzed maggot meal.

Furthermore, the addition of maggot meal, whether non-hydrolyzed or hydrolyzed, influences feed intake (FI) differently. Non-hydrolyzed maggot meal tends to increase FI, particularly at higher supplementation levels. In contrast, hydrolyzed maggot meal maintains consistent FI levels across different supplementation levels. This discrepancy is attributed to the chitin content present in non-hydrolyzed maggot meal, which can affect digestibility and feed intake.

The hydrolysis process, facilitated by crude enzymes from Tempeh yeast, plays a pivotal role in enhancing nutrient availability in maggot meal. Chitinase activity in Tempeh yeast contributes significantly to this process, breaking down chitin and improving nutrient absorption. These findings suggest that hydrolyzed maggot meal is a promising addition to Sentul chicken diets, with optimal performance observed at 4% and 6% supplementation levels.This supplementation not only improves chicken performance but also enhances the digestibility of protein and crude fiber, making it a valuable option for poultry nutrition

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AUTHORS' CONTRIBUTIONS

S. Rahayu conceived and designed the experiment and wrote the paper, *W. Suryapratama* supervised the study and verified the manuscript, *T. Widiyastuti* field researcher and collected data, *B. Hartoyo* laboratory researcher and manager, *EA Rimbawanto* analysed the data.

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Table 1: Nutrient composition of non-hydrolyzed and hydrolyzed maggot meal (% dry matter)

Nutrients	Non-hydrolyzed	Hydrolyzed
Dry matter (%)	96.11	93.01
Protein (%)	43.33	36.62
Fat (%)	23.75	22.29
Crude fiber (%)	26.51	19.80
Ash (%)	14.04	18.34
Nitrogen Free Extract (NFE) (%)	0.4	4.78

Table 2: Composition of experimental diets, as fed basis

Ingredients (%)	R0	R1	R2	R3 (%)	R4	R5	R6
Corn	50	50	50	50	50	50	50
Soybean meal	15	15	15	15	15	15	15
Fish meal	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Rice bran	21.4	21.4	21.4	21.4	21.4	21.4	21.4
Vegetable oil	4	4	4	4	4	4	4
CaCO3	1	1	1	1	1	1	1
Lysine	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Methionine	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Mineral Mix[a]	1	1	1	1	1	1	1
Maggot meal	0	2	4	6	2	4	6
Nutrients composition							
Dry matter (%)	90.53	90.54	90.46	90.47	90.88	90.69	90.70
Protein (%)	17.94	18.61	19.60	20.73	18.25	19.28	20.13
EM (Kcal/kg)	3352	3431	3509	3588	3415	3477	3540
Fat (%)	4.21	5.63	6.41	7.93	4.28	4.41	5.30
Crude fiber (%)	9.07	11.35	13.82	14.04	9.89	10.69	11.27

Mineral mix composition, each 10 kg contains: Vitamin A= 12.000.000 IU; Vitamin D3= 2.000.000 IU; Vitamin E= 8.000 IU; Vitamin K= 2.000 mg; Vitamin B1= 2.000 mg; Vitamin B2= 5.000 mg; Vitamin B6= 500 mg; Vitamin B12= 12.000 µg; Vitamin C= 25.000 mg; Calcium-D-panthothenate= 6.000 mg; Niacin= 40.000 mg; Choline chloride= 10.000 mg; Manganese= 120.000 mg; Iron= 20.000 mg; Iodine= 200 mg; Zinc= 100.000 mg; Cobalt= 200 mg; Copper= 4.000 mg.

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Table 3: Chitinase and protease activity of Tempeh yeast

Enzymes	Spesific activity (unit/mg)
Chitinase	4.01
Protease	10.42

Table 4: Feed Intake (FI), Weight Gain (WG), Total Weight (TW) and Feed Conversion Ratio (FCR) of Sentul Chicken Fed Non-hydrolized and Hydrolyzed Maggot Meal

Treatments	Feed Intake (g/b)*	Weight Gain (g/b)**	FCR**	Total Weight (g/b)**
R_0	1613.38±112.85^{a}	367.15 ± 30.49^{a}	4.43±0.63^{bc}	403.05±30.49^{a}
R_1	1761.14±41.02^{ab}	366.77 ± 24.20^{a}	4.78±0.48^{c}	403.73±24.20^{a}
R_2	1784.50±68.29^{b}	370.84 ± 16.63^{a}	4.82±0.29^{c}	406.24±16.63^{a}
R_3	1817.03±44.15^{b}	417.31 ± 30.92^{ab}	4.37±0.42^{bc}	455.11±30.92^{ab}
R_4	1735.70±18.98^{ab}	493.82 ± 16.89^{b}	3.52±0.12^{ab}	530.32±16.89^{b}
R_5	1703.84±8.95^{ab}	583.06 ± 49.89^{c}	2.93±0.25^{a}	620.26±49.89^{c}
R_6	1751.06±43.23^{ab}	610.05 ± 3.18^{c}	2.61±0.51^{a}	648.15±3.18^{c}

R_0 = basal feed (control), R_1 = R_0 + 2% nonhydrolyzed maggot meal, R_2 = R_0 + 4% nonhydrolyzed maggot meal, R_3 = R_0 + 6% nonhydrolyzed maggot meal, R_4 = R_0 + 2% hydrolyzed maggot meal, R_5 = R_0 + 4% hydrolyzed maggot meal, R_6 = R_0 + 6% hidrolisat tepung maggot. ^{a,b,c} Value in the same column with different letter are significantly different (P<0.05)

Table 5: Crude Protein (CPD) and Crude Fiber digestibility (CFD) of Sentul Chicken Feed Supplemented with Nonhydrolyzed and Hydrolyzed Maggot Meal

Treatments	Crude Protein Digestibility (%)**	Crude Fiber Digestibility (%)*
R_0	82.16 ± 1.46^{a}	60.01 ± 2.40^{a}
R_1	83.71 ± 1.12^{a}	69.99 ± 1.31^{b}
R_2	86.22 ± 2.00^{b}	75.18 ± 3.79^{c}
R_3	88.12 ± 0.45^{bc}	77.36 ± 0.46^{c}
R_4	89.55 ± 0.67^{cd}	73.82 ± 1.75^{c}
R_5	91.11 ± 0.87^{d}	78.85 ± 2.14^{d}
R_6	93.14 ± 0.15^{e}	83.90 ± 0. 40^{e}

R_0 = basal feed (control), R_1 = R_0 + 2% nonhydrolyzed maggot meal, R_2 = R_0 + 4% nonhydrolyzed maggot meal, R_3 = R_0 + 6% nonhydrolyzed maggot meal, R_4 = R_0 + 2% hydrolyzed maggot meal, R_5 = R_0 + 4% hydrolyzed maggot meal, R_6 = R_0 + 6% hidrolisat tepung maggot. ^{a,b,c} Value in the same column with different letter are significantly different (P<0.05)

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REFERENCES

1. **Asmara IY** Risk Status of Selected Indigenous Chicken Breeds in Java, Indonesia: Challenges and Opportunities for Conservation. [Dissertation]. Research Institute for the Environment and Livelihoods, Faculty of Engineering, Health, Science and the Environment, Charles Darwin University, Darwin, Australia. 2014.

2. **Asmara IY, Widjastuti T, Setiawan I, Abun and R Partasasmita** The growth performances and the gut health parameters of Sentul chickens supplemented with various dosage of turmeric powder. *Nusantara Bioscience* 2018; **10(3):** 121-125.

3. **Abduh MY, Perdana MP, Bara MA, Anggraeni LW and RE Putra** Effects of aerationrate and feed on growth, productivity and nutrient composition of black soldier fly (*Hermetia illucens* L.) larvae. J*. of Asia-Pacific Entomol.* 2022; **25:** 101902.

4. **Sanou AG, Sankara F, Pousga S, Coulibaly K, Nacoulma JP, Kenis M, Clottey VA, Nacro S, Somda I and I Ouédraogo** Indigenous practices in poultry farming using maggots in western Burkina Faso. *J. of Insects as Food and Feed.* 2016; **1(1):** 1-10.

5. **Bovera FG, Piccolo L and S Gasco** Yellow mealworm larvae (*Tenebriomolitor L*.) as a possible alternative to soybean meal in broiler diets. *British Poultry Sci.* 2015; **56(5):** 569–575.

6. **Shah Z** Effect of replacing soy bean meal with maggot meal on the production performance and egg quality traits of commercial white leg horn layers. *J. Dairy Vet. Anim. Res.* 2020; **9(6):** 166–170.

7. **Hermanns D, Martel A, Garmyn A, Verlinden M, Heyndrickx M, Gantois I, Haesebrouck F and F Pasmans** Application of medium chain fatty acids in drinking water increases Campylobacter jejuni colonization threshold in broiler chicks. *Poult Sci.* 2012; **91(7):** 1733–1738.

8. **Zeiger K, Popp J, Becker A, Hankel J, Visscher C and G Kleine** Lauric acid as feed additive – An approach to reducing Campylobacter spp. in broiler meat. *PLoS ONE.* 2017; **12(4):** e0175693.

9. **Finke MD** Estimate Chitin in Raw Whole Insects. *Zoo Biol.* 2007; **26:** 105-115.

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10. **Marbun NGT, Tafsin M and YL Henuk** Efficiency Utilization of Protein and Energy of Maggot Black Soldier Fly at Different Phase on Chicks. *IOP Conference Series: Earth and Environ. Sci.* 2021; **782(2):** 1-5.

11. **Khempaka S, Chitsatchapong C and W Molee** Effect of chitin and protein constituents in shrimp head meal on growth performance, nutrient digestibility, intestinal microbial populations, volatile fatty acids, and ammonia production in broilers. *J. Appl. Poult. Res.* 2011; **20:** 1–11.

12. **Mahata M, Shinya S, Masaki E, Yamamoto T, Ohnuma T, Brzezinski R, Mazumder TK, Yamashita K, Narihiro K and T Fukamizo** Production of chitooligosaccharides from Rhizopus oligosporus NRRL2710 cells by chitosanase digestion. *Carbohydrate Res.* 2014; **383:** 27–33.

13. **Liu Y, Liao W and S Chen** Co-production of lactic acid and chitin using a pelletized filamentous fungus Rhizopus oryzae cultured on cull potatoes and glucose. *J. Appl.Microbiol.* 2008; **105:** 1521-1528.

14. **Walter HE** Proteinases (proteinas substrates). Method with haemoglobin, casein and azocoll as substrate. In: Bergmeyer J and M Grassl, (Eds.). Methods of Enzymatic Analysis, 3rd ed. Verlag Chemie, Weinheim, 1984: 270–278.

15. **Rahayu S, Tanuwidjaja F, Rukayadi Y, Suwanto A, Suhartono MT, Hwang JK and YR Pyun** Study of thermostable chitinase enzymes from Indonesian *Bacillus* K29-14. J. of Microbiol. and Biotechnol. 2004; **14(4):** 647-652.

16. **AOAC.** Official methods of analysis. Association of Official Analytical Chemist. 19st ed. Washington DC, USA. 2012.

17. **Wolynetz MS and IR Sibbald** Relationships Between Apparent and True Metabolizable Energy and the Effects of a Nitrogen Correction. *Poult. Sci.* 1984; **63:** 1386-1399.

18. **Hidayat C, Sumiati and S Iskandar** Growth responses of native chicken Sentul G-3 on diet containing high rice-bran supplemented with phytase enzyme and ZnO. *Indonesian J. of Vet. and Anim. Sci.* 2014; **19(3):** 193-202

19. **Donadelli RA, Stone DA, Aldrich CG and RS Beyer** Effect of fiber source and particle size on chick performance and nutrient Utilization. *Poult. Sci.* 2019; **98(11):** 5820-5830.

20. **Nursiam I, Ridla M, Nahrowi N, Hermana W and A Jayanegara** A Meta-Analysis of Fiber Ratio Effects on Growth Performance, Gastrointestinal Traits and Nutrient Digestibility in Broiler. *J. World Poult. Res.* 2022; **12(1):** 10-15.

21. **Maharjan P, Mullenix G, Hilton K, Caldas J, Beitia A, Weil J, Suesuttajit N, Kalinowski A, Yacoubi N, Naranjo V, England J and C Coon** Effect of digestible amino acids to energy ratios on performance and yield of two broiler lines housed in different grow-out environmental temperatures. *Poult. Sci.* 2020; **99:** 6884–6898.

22. **Spranghers T, Ottoboni M, Klootwijk C, Ovyn A, Deboosere S, De Meulenaer B, Michiels J, Eeckhout M, De Clercq P and S De Smet** Nutritional composition of Black Soldier Fly (*Hermetia illucens*) prepupae reared on different organic waste substrates. *J. Sci. Food Agric.* 2017; **97:** 2594–2600.

23. **Yoon BK, Jackman JA, Valle-González ER and NJ Cho** Antibacterial free fatty acids and monoglycerides: biological activities, experimental testing, and therapeutic applications. *Internat. J. of Molecular Sci.,* 2018; **19(4):** 1114-1121.

24. **Puteri NI** Gushairiyanto and Depison Growth Patterns, Body Weight, and Morphometric of KUB Chicken, Sentul Chicken and Arab Chicken. *Buletin of Anim. Sci. 2020*; **44(3):** 67-72.

25. **Mundarasep MJ, Iksan MR, Fatwa B, Dawanto J, Asmawati and M Idrus** Effect of addition maggot-based amino acid solution from black soldier fly (*Hermetia illucens*) on the final weight of Balitnak Superior Native Chickens (KUB). *J. of Integrated Anim. Sci. Technol.* 2021; **1:** 15-22.

26. **Atchade GST, Houndonougbo EFM, Chrysostome CAAM and GA Mensah** Digestibility of feeds in broiler chicken (*Galus galus* linnaeus, 1758) in Africa: a review. *Int. J. Biol. Chem. Sci.* 2019; **13(2):** 1127-1139.

27. **Naibaho GG, Yunilas, Hasnudi N, Ginting and B Manullang** Digestibility of Maggot Black Soldier Fly (*Hermetia illucens*) Flour in Ration of Kampong Chicken. *J. of Integr. Anim. Husband.* 2021; **9(1):** 1-8.

28. **Park SIK, Chang BS and SM Yoe** Detection of Antimicrobial Substance from Larvae of the Black Soldier Fly, *Hermetia illucens* (Diptera: Stratiomyidae). *Entomological Res.* 2014; **44(2):** 58-64.

29. **Auza AA** Potential utilization of maggot flour (*Hermetia illucens*. l) as an antibacterial and protein source in free-range chicken rations. Thesis. University of Hasanuddin. 2021.