International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 49 No. 1 February 2025, pp. 189-197

Substitution Of Commercial Feed With Varying Levels And Ages Of Maggots For Laying Hens

Andi Nurdiansyah [1], Budi Indarsih[2*], Bulkaini[2] and I Ketut Gede Wiryawan [2]

Postgraduate Student of Animal Resources Management Study Program, Faculty of Animal Science, University of Mataram, Indonesia.

[2] Faculty of Animal Science, University of Mataram

[2*]Coresponding author: budiindarsih@unram.ac.id

Abstract – This study aimed to investigate the potential of replacing commercial feed with maggots at various ages and levels to assess its impact on the productive performance and egg quality of Hy-Line Brown laying hens. A total of 108 hens, aged 32 weeks, were assigned to a Completely Randomized Design with two factors: maggot levels (0%, 3%, 5%, and 7%) and maggot ages. The substitution of commercial feed with maggots at different ages and levels did not significantly affect feed intake, feed conversion ratio (FCR), egg production, and egg mass production (P>0.05), except for egg weight, which was influenced by the interaction of both factors (P<0.01). Egg yolk color, albumen, and yolk weights were unaffected by maggot age, while maggot level only impacted egg weight. The interaction between factors influenced egg yolk color and albumen weight. The most favorable treatment for the age factor was M1 and M2, while the optimal maggot level occurred at 7% (M3). The interaction of W2M3 generally produced the best performance in terms of egg weight and egg quality,

Keywords – Maggot BSF, Hy-Line Brown, Egg quality.

Introduction

The growing global population has significantly increased the demand for livestock products such as meat and eggs, as these serve as vital sources of animal protein. However, the livestock industry faces significant challenges due to the limited and costly availability of traditional feed ingredients like soybeans and fishmeal. This situation has spurred the search for alternative feed sources that are more affordable, sustainable, and environmentally friendly. Among these alternatives, the larvae of the Black Soldier Fly (*Hermetia illucens*) or BSF, commonly known as maggots, have gained considerable research attention. These larvae are highly efficient at decomposing organic waste, with a remarkable capacity for rapid consumption. Their short lifecycle and high biomass production make them an appealing option for various applications, including livestock feed. Studies have identified maggot meal as a viable alternative protein source for poultry feed (Sheppard et al., 2002; Teguia et al., 2002; Ogunji et al., 2008), offering a sustainable and environmentally friendly solution to meet the increasing demand for protein while addressing environmental challenges. The inclusion of maggots in poultry diets has been tested in, in wild ducks (Gariglio et al., 2019), broilers (Khan et al., 2023 ; Doper et al., 2024) and laying Pekin ducks (Indarsih et al., 2024). In the latter study, feeding laying ducks with a diet containing 200 g/kg of live maggots resulted in higher egg weights (67.2 ± 1.4 g/egg) significantly compared to the control (62.2 ± 1.4 g) and diets with 100 g/kg (62.1 ± 1.5 g) and 150 g/kg (63.3 ± 2.1 g) maggots under a conventional feeding system.

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
© 2025 Scholar AI LLC.
https://ijpsat.org/
Vol. 49 No. 1 February 2025, pp. 189-197

However, the effectiveness of using maggots as a replacement for commercial feed in laying hens requires further exploration. Variables such as the proportion of maggots in the diet and the age of the maggots may influence the nutritional value of the feed and the performance of the hens. This study aims to investigate the effects of substituting commercial feed with varying levels and ages of maggots on the performance of laying hens, focusing on productive performance and egg quality. The study seeks to offer a cost-effective feed alternative while contributing to sustainability in poultry farming.

Materials and methods

Experimental design and animal feeding

This study used a completely randomized design with two factors (age and levels of BSF maggots). A total of 120, 32-wks-old Hy-line Brown laying hens were randomly allocated among four treatment groups of BSF levels : 0% (M0), 3% (M1), 5% (M2) and 7% (M3) where BSF maggots in a mixture of commercial and three different ages of BSF feed (1, 2 and 3 wks. of BSF) were fed or W1, W2 and W3. We used live maggots in this study. The experimental animals were housed in wire cages (size: 120× 55 × 35 cm) for 6 birds with 3 replicates per treatment in open house system. The ingredient and nutrient compositions of the experimental diets are shown in Table 1. As presented in this table that energy content was from 2766 to 2972 kcal/kg diet whilst crude protein was from 17.5 to 18.13 %. The feed allocation was restricted to 120 g/bird/day according to Indonesian National Standard for feeding laying hens and drinking water was provided *ad libitum* for 8 weeks (from 32 to 40 wks of age). The poultry housing temperature, relative humidity, and lighting availability were recorded. There was no vaccination and medication implemented.

Black Soldier Fly Larvae Production

BSF larvae was purchased from a local farm close to the experimental site which was fed a mixture of waste from the local market. We guarantee the age of the larvae within one or two days because this farm hatches BSF eggs every day. Before the study began, the dry matter (DM) content of the larvae was analyzed and found to average 25%. This value was used to fix the daily live larvae portions, based on a total estimated DM intake of 120 g/day. For the 3 % treatment group, hens were fed 4,8 g of live larvae per day, while the 5% and 7% treatment groups received 8 and 11,2 g of larvae per day throughout the study.

Table 1. Ingredients and nutrient contents of the experimental diet

Feed Ingredients	Dietary treatment			
	M0 (0%)	M1 (3%)	M2 (5%)	M3 (7%)
Corn (%)	49.02	48.02	47.35	46.69
Rice bran (%)	16.34	15.34	14.68	14.00
Concentrate (%)	32.68	31.68	31.01	30.35
Minerals (%)	1.96	1.96	1.96	1.96
BSF Maggots (%)	0	3.00	5.00	7.00
Total (%)	100.0	100.0	100.0	100.0
Calculated nutrient contents	M0 (0%)	M1 (3%)	M2 (5%)	M3 (7%)
ME (kcal/kg diet)	2766	2854	2913	2972
Crude protein (%)	17.5	17.8	18.0	18.13

Crude fibre (%)	7.4	7.6	7.7	7.8
Ether extract	5.4	6.1	6.6	7.01
Calcium	3.94	3.74	3.61	3.47
Phosphor	0.38	0.39	0.40	0.41
Lysine	0.56	0.57	0.58	0.59
Methionine	0.26	0.26	0.26	0.26

Notes : M0 – No maggots; M1-3% maggots; M2-5% maggots M3-7% maggots ; ME: Metabolizable Energy

Production performance and egg quality parameters

A freshly prepared feed mixture was provided to the birds daily. Egg production and egg weights were recorded daily, while feed intake was monitored weekly for each replicate. The daily feed intake was determined by dividing the total weekly feed intake by seven. Egg quality was evaluated weekly by randomly selecting 20 eggs from each treatment group on the same day. This process was conducted during weeks 20 to 28, and the results were expressed as average values. Egg qualities were focused on egg weight which was recorded using a digital egg balance with an accuracy of ± 0.01 g. Other egg qualities were albumen and yolk weights were measured after breaking out the shell. Eggshell thickness (mm) was determined with a digital Mitutoyo absolute thickness gauge, based on the average of three measurements taken from the egg's equator. Yolk color was assessed with a Roche yolk color fan with 1 to 15 scale

Data analysis

The data were subjected to analysis of variance (ANOVA) following the General Linear Model (GLM) procedure of SPSS version 15.0 (2006). The differences between the means of groups were identified by the test of Duncan's at 5% significance level.

Results and discussion

Production performance

Substitution of commercial feed with maggots of different ages and levels in Hy-Line Brown laying hens did not significantly affect feed intake, FCR, egg production, and egg mass production, except egg weight was affected by both factors and their interactions (P<0.01) (Table 2).

Table 2. Productivity of Hy-Line Brown laying hens fed with maggots of different ages and levels

Factor	Feed intake (g /bird/day)	Feed Conversion Ratio (FCR)	Egg Weight (g)	Hen day Egg Production (HDEP (%)	Egg Mass Production (g)
Age			**		
W1	119.1 ± 0.71	2.88 ± 1.04	62.43 ± 1.16[a]	75.69 ± 20.32	47.18 ± 12.52
W2	119.2 ± 0.57	2.62 ± 0.71	61.57 ± 1.43[b]	80.06 ± 15.86	49.39 ± 10.22
W3	119.2 ± 0.52	2.74 ± 0.96	61.18 ± 1.43[b]	79.12 ± 17.47	48.45 ± 10.99
SEM	0.077	0.159	0.198	3.167	2.008
Level					

M0	119.6 ± 0.25	2.78 ± 0.33	61.48 ± 1.10^{b}	84.92 ± 10.58	52.21 ± 6.63
M1	119.5 ± 0.27	2.77 ± 1.16	61.51 ± 1.50^{b}	73.15 ± 21.85	45.13 ± 13.99
M2	119.1 ± 0.43	3.03 ± 0.95	61.12 ± 1.55^{b}	78.37 ± 19.50	47.83 ± 11.87
M3	118.5 ± 0.71	2.37 ± 0.84	62.81 ± 0.92^{a}	76.72 ± 16.61	48.20 ± 10.52
SEM	0.089	0.183	0.228	3.657	2.318
Interaction					
W1M0	119.7 ± 0.28	2.35 ± 0.35	61.45 ± 1.56^{cde}	86.11 ± 11.12	52.90 ± 7.05
W1M1	119.6 ± 0.21	2.92 ± 0.90	62.39 ± 0.55^{abc}	73.41 ± 21.22	45.70 ± 13.00
W1M2	118.9 ± 0.61	3.31 ± 1.31	62.71 ± 0.69^{ab}	67.46 ± 24.18	42.23 ± 14.95
W1M3	118.4 ± 0.63	2.94 ± 1.26	63.19 ± 0.93^{a}	75.79 ± 21.51	47.89 ± 13.51
W2M0	119.4 ± 0.27	2.32 ± 0.30	61.42 ± 0.53^{cde}	85.91 ± 9.69	52.80 ± 6.22
W2M1	119.4 ± 0.20	2.94 ± 0.98	60.94 ± 1.89^{def}	74.80 ± 20.16	45.84 ± 13.35
W2M2	119.3 ± 0.30	2.62 ± 0.79	60.75 ± 0.61^{ef}	81.15 ± 19.37	49.36 ± 12.05
W2M3	119.5 ± 0.82	2.59 ± 0.56	63.17 ± 0.80^{a}	78.37 ± 12.75	49.54 ± 8.49
W3M0	119.5 ± 0.18	2.44 ± 0.38	61.55 ± 1.11^{bcde}	82.74 ± 11.92	50.92 ± 7.27
W3M1	119.4 ± 0.38	3.33 ± 1.60	61.20 ± 1.47^{cde}	71.23 ± 26.55	43.83 ± 17.11
W3M2	119.2 ± 0.23	2.37 ± 0.30	59.91 ± 1.53^{f}	86.51 ± 8.27	51.88 ± 6.04
W3M3	118.7 ± 0.72	2.81 ± 0.80	62.08 ± 0.60^{abcd}	75.99 ± 16.61	47.14 ± 10.26
SEM	0.154	0.317	0.396	6.334	4.016
Probability					
Age	0.945	0.512	0.000	0.593	0.739
Level	0.197	0.068	0.000	0.150	0.199
Age x Level	0.208	0.537	0.009	0.650	0.807

Notes: $^{a\text{-}f}$ Means with different superscripts in the same column are significantly different ($p<0.05$) and very significantly different ($P<0.01$). SEM: Standard Error of Means. W1 (1-week-old maggots). W2 (2-wks-old maggots). W3 (3-wks-old maggots). M0 (0% maggot level). M1 (3% maggot level). M2 (5% maggot level). M3 (7% maggot level).

Feed intake

Feed intake was not influenced by age, level factors, or their interactions, with values ranging from 118 to 119 g/bird/day. This consistency in feed intake can be attributed to the uniform feed allocation of 120 g/day per bird. The findings align with those of Afikasari *et al*. (2022), who reported feed intake of 119.19 g/bird/day when 5% maggot meal was included in the diet and 117.16 g/bird/day with 10% maggot meal. However, these results differ slightly from those of Sumiati et al. (2022), who observed lower feed intake of 112 g/bird/day and 111 g/bird/day with the maggot meal inclusion levels (5% and 10%) respectively. The variation in results may be attributed to differences in environmental conditions and the age of the laying hens, protein content in the feed, and the portion sizes provided.

FCR

The FCR value was not significantly different in the different age and maggot levels or their interactions were not significantly different (P>0.05). In the maggot age factor, chickens offered W2 maggots had the best FCR value (2.62±0.71) compared to W1 (2.88±1.04) and W3 (2.74±0.96), indicating better feed efficiency which may be due to the more optimal nutritional profile of W2 maggots. While the maggot level factor offered the best FCR value was seen at the M3 substitution level (2.37±0.84), indicating that the addition of maggots at the highest level resulted in optimal feed conversion efficiency. In the interaction between age and maggot level on the FCR variation ranging from 2.35–3.33. However, in the interaction between age and level, feeding the highest maggot level resulted in the lowest FCR (W1M3, W2M3 and W3M3), which means the influence of maggot level was more dominant than maggot age. This value is more efficient compared to the study by Sumiati et al. (2022), where feeding 5% maggot meal resulted in a FCR of 2.81 ± 0.67. The improved FCR with maggot meal feeding is attributed to changes in small intestine morphometry, enzymatic activity, and caecal microbial activity, which were more favorable than in the comparison group (Moniello et al. 2019).

Egg Weight

The age of maggots and the level of their inclusion in the ration both had a highly significant impact on egg weight, including their interaction (P<0.01). Among the maggot age treatments, the highest egg weight was observed in young maggot W1 (62.43±1.16 g), while for the level factor, M3 yielded the highest value (62.81±0.92 g). Egg weight tended to decrease as the age of the maggots used increased, indicating that younger maggots, with their higher nutritional value and larger feeding portions, are more effective in supporting the production of heavier eggs. The interaction between maggot age and level in the diet showed variation across treatments The highest egg weights were recorded in treatments W3M1 (63.19±0.93 g) and W3M2 (63.17±0.80 g), while the lowest value was observed in W2M3 (59.91±1.53g). These findings suggest that maggots with a high protein content, combined with greater inclusion levels, contribute significantly to increased egg weight. Specifically, the use of 1-week-old maggots, which possess higher nutritional quality, tends to result in more consistent and greater egg weights. The egg weights reported in this study surpass the findings of Dörper et al. (2024), who noted that a 5% inclusion of black soldier fly (BSF) larvae produced eggs weighing 56.80 g each. Maggot levels can significantly affect egg weight because maggots are rich in nutrients such as protein, fat, and minerals, which are essential for growth and egg production in chickens (Makkar and Becker, 2009). Including maggots in the feed can improve feed quality, enhance digestion, and increase metabolic efficiency in chickens. As a result, chickens fed a higher level of maggots may produce larger eggs, as better nutrient intake supports optimal egg formation. Additionally, changes in gut microbiota, gut morphology, and enzymatic activity due to maggot inclusion may also play a role in improving nutrient absorption, which in turn affects egg weight (Makkar and Becker, 2009).

HDEP

The factors of maggot age and inclusion levels did not have a significant effect on Hen-Day Egg Production (HDEP) in tilapia, and no interaction was observed (P>0.05). For the maggot age factor, the highest HDEP value was recorded in treatment M2 (80.06±15.86%), while the lowest was in treatment M1 (75.69±20.32%). Regarding the maggot inclusion level, treatment M0 yielded the highest and most favorable HDEP value (84.92±10.58%), whereas treatment T1 had the lowest (73.15±21.85%). Factors influencing HDEP include the proportion of maggots in the feed, the nutritional quality of the maggots, and the overall nutritional composition of the feed mixture. Incorporating up to 5% black soldier fly (BSF) meal in feed has been shown to enhance the HDEP of laying hens (Aksara *et al*., 2023). The high protein and fat content of maggots contributes to improved feed quality, enabling chickens to utilize nutrients more efficiently (Raharja dan Astawa, 2024). Similarly, Sumiati *et al*. (2022) found that incorporating 5%, 10%, and 15% maggot meal into the ration resulted in HDEP values of 73.57%, 64.10%, and 59.65%, respectively. These variations are attributed to differences in the age of the chickens used, which impacts egg production.

International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

https://ijpsat.org/
Vol. 49 No. 1 February 2025, pp. 189-197

Egg Mass Production

There was no effect of larvae consumption both age and levels or their interaction (P>0.05) on egg mass production. However, the M2 treatment showed a tendency to produce higher egg mass (49.39±10.22 g) compared to M1 and M3. For the maggot inclusion level, treatment M0 (48.92±10.58 g) exhibited the highest egg mass compared to other substitution levels. The interaction between maggot age and inclusion level resulted in egg mass production ranging from 42.23 g to 52.90 g. The highest values were observed in treatments W1M0 (52.90±7.05 g) and W2M0 (52.80±6.22 g), while the lowest was recorded in W2M1 (42.23±14.95 g), indicating suboptimal outcomes. These findings suggest that feed, whether or not supplemented with maggots, is sufficient to produce optimal egg mass weights. However, the study by Tahamtani *et al*. (2021) who used Bovans White laying hens were provided with 0, 10, 20% or *ad libitum* daily portions of live larvae from 18 to 30 wk of age reported egg mass production ranging from 53.59 to 54.02 g. In other words, feed containing maggots from Black Soldier Fly can increase feed efficiency and improve the performance of laying hens, including increasing egg mass production and egg quality.

Internal quality of eggs

In regard to internal egg quality, this study reported that maggot age does not affect quality, level affects albumen weight and the interaction of both factors affects albumen color and weight (Tabel 3).

Table.3. Internal quality of Hy-Line Brown laying hens fed with maggots of different ages and levels from 32 to 40 wks of age

Factor	Yolk Color	Albumen Weight (g)	Yolk Weight (g)
Age			
W1	9,75 ± 1,48	38,52±3,45	15,39±1,56
W2	9,36 ± 1,17	37,60±4,16	14,84±1,31
W3	9,61 ± 0,93	37,46± 2,97	15,30±1,62
SEM	0,176	0,531	0,258
Level		**	
M0	9,96 ± 1,19	39,33±3,14^{a}	15,04±1,53
M1	9,48 ± 1,31	36,31±4,24^{c}	15,06±1,41
M2	9,48 ± 0,89	37,49±2,61^{bc}	15,17±1,86
M3	9,37 ± 1,39	38,31±3,52^{ab}	15,44±1,22
SEM	0,203	0,614	0,298
Interaction	**	**	
W1M0	10,22±1,09^{abc}	41,65±3,10^{a}	15,30±1,17
W1M1	8,67±1,50^{d}	38,06±2,98^{bc}	15,41±0,88
W1M2	9,44±1,01^{bcd}	37,67±1,93^{bc}	15,27±2,68
W1M3	10,67±1,58^{a}	36,72±3,77^{cd}	15,59±1,10
W2M0	9,11±1,27^{cd}	37,56±3,31^{bc}	14,60±1,61

W2M1	10,33±1,00^{ab}	34,13±4,75^{d}	14,64±1,14
W2M2	9,44±0,88^{bcd}	37,83±3,56^{bc}	14,62±1,11
W2M3	8,56±0,88^{d}	40,89±1,93^{ab}	15,49±1,32
W3M0	10,56±0,73^{ab}	38,79±1,27^{abc}	15,21±1,83
W3M1	9,44±0,88^{bcd}	36,74±4,23^{cd}	15,12±2,00
W3M2	9,56±0,88^{bcd}	36,97±2,29^{cd}	15,61±1,48
W3M3	8,89±0,33^{d}	37,34±3,32^{cd}	15,25±1,34
SEM	0,351	1,063	0.516
Probability			
Umur	0,289	0,312	0,271
Level	0,172	0,006	0,757
Age x Level	0,000	0,003	0,944

Notes: $^{a-f}$ Means with different superscripts in the same column are significantly different (P<0.05) and very significantly different (P<0.01). SEM: Standard Error of Means. W1 (1-week-old maggots). W2 (2-wks-old maggots). W3 (3-wks-old maggots). M0 (0% maggot level). M1 (3% maggot level). M2 (5% maggot level). M3 (7% maggot level).

Yolk Color

The factors of maggot level and age did not show significant differences (P>0.05), but the interaction between these two factors had a very significant impact (P<0.01) on yolk color. Although the age of maggots did not show a significant effect, the highest value was observed in the W1 treatment (9.75±1.48). The level factor M0 (without maggots) also showed the highest value. The interaction between the age and level treatments indicated that the control group (without maggots) with the highest maggot level produced eggs with the most intense yolk color. This suggests that the yolk color is influenced by the feed (such as corn), and larger maggots require more feed, which may contain carotenoids like lutein and zeaxanthin that contribute to the yellow color of the yolks. If maggots consume more carotenoids from their feed, chickens that eat these maggots will produce eggs with a more vibrant yellow yolk. However, as pointed out by Indarsih et al. (2024), maggots do not affect yolk color, and in their study, the dark yolk color in Pekin duck eggs was attributed to green algae.

Albumen Weight

The albumen weight value of the maggot age factor did not have a significant effect (P>0.05), while the maggot level factor showed a very significant difference (P<0.01) on albumen weight. Then there was a very significant interaction (P<0.01) both factors. The highest value in the age factor was in the W1 treatment (38.52±3.45 g). Interaction W1M0 had the highest albumen weight (41.65±3.10 g) had statistically similar value on W2M3 (40,89±1,93 g). It means that 7% maggot in the experimental diet is able to replace commercial fed. The results of this study are much higher than the study conducted by Dörper et al., (2024) using 5 and 10% maggot larvae, and also the use of maggot meal added with maggot oil only obtained an albumen weight value of 31.20-32.00. The study of Bejawi et al., (2024) found that the use of maggot oil in feed at a level of 4% can improve the quality of chicken eggs. In addition, factors such as nutritional balance in feed, chicken health, and optimal farm management also play an important role in determining the weight and quality of egg albumen and the content of protein and fat in feed and maggots in rations

Yolk Weight

The yolk weight value of the age factor and the maggot level factor did not have a significant effect and there was no interaction (P>0.05) on the yolk weight. The highest value for the age factor was found in the W1 treatment (15.39±1.56 g). For the maggot level factor, the highest treatment was seen in the M3 group (15.44±1.22 g) and M2 (15.17±1.86 g). The interaction value between age and maggot level on yolk weight (Table 3), but the highest value was recorded in the W3M2 treatment (15.61±1.48 g). These results indicate that the use of 3-wks-old maggots and the addition of more maggots (5% maggots) can increase the yolk weight, which is likely the fat and protein content in maggots also provides sufficient energy for chickens, thereby helping the egg formation process more efficiently. In addition, the amino acids in maggots can play a role in protein synthesis which is important for egg development, especially egg yolk which is rich in nutrients. By providing quality maggots, chickens will produce larger eggs and more optimal egg yolk weight. Thus, this is the effect of the higher protein and energy content in the feed mixture. This study is lower than Dörper et al., (2024) who the use of 5 and 10% maggot larvae, obtained yolk weight values of 17.50 and 17.60. This is likely the use of high maggot meal and high nutritional value in feed. Study by Aqila et al. (2021) shows that the use of maggot meal in laying hen feed does not have a significant effect on overall egg weight, which includes egg yolk weight. The high protein and fat content in maggot meal is able to meet the nutritional needs of laying hens, resulting in good egg yolk quality (Bejawati et al., 2024) .

Conclusion

Feeding maggots of varying ages and levels to Hy-Line Brown laying hens did not significantly affect overall productivity, except for egg weight, where an interaction between both factors was observed significantly (P<0.01). Internal egg quality remained unaffected by the age of the maggots, although the level of maggot feeding influenced albumen weight. The interaction of maggot age and level impacted both egg yolk color and albumen weight. The most effective age treatments were W1 and W2, while the optimal maggot level was M3 (7%). The interaction of W2M3 yielded the best results for egg weight and albumen weight, making it the most beneficial for layer chicken farms.

REFERENCES

[1]. Afikasari D., Rifa'i., Angriawan R., Candra D. A. Maskur C. A., dan Safikoh D. K. 2022. Pengaruh Pemberian Maggot (BSF) *Black Soldier Fly* ke Dalam Ransum Pakan Terhadap Konsumsi Pakan Ayam Petelur (The (Effect of Adding Black Soldier Fly Maggot (BSF) to the Feed Ration on Feed Consumption of Laying Hens).Jurnal Sains Peternakan. 10 (1): 1-4.DOI**:** https://doi.org/10.21067/jsp.v10i1.7249

[2]. Aqila H. R., Latif H., dan Daud M. 2021. Pengaruh Penggunaan Tepung Maggot (Hermetia Illucens) dan Sprouted Fodder for Chicken (SF2C) dalam Pakan Fermentasi terhadap Produksi dan Kualitas Telur Ayam Hibrida. Jurnal Ilmiah Mahasiswa Pertanian. 6 (3); 79-87. www.jim.unsyiah.ac.id/JFP

[3]. Bejawati N., Darmawan H., Supartini N. 2024. Penggunaan Minyak Maggot pada Pakan Terhadap Kualitas Telur Ayam Ras. JIPHO (Jurnal Ilmiah Peternakan Halu Oleo). 6 (4); 366-371. DOI: 10.56625/jipho.v6i4.97

[4]. Indarsih B, Tamzil M H, Haryani N K D, Sukartha Jaya I N and Asnawi 2024. Live maggots for laying Pekin ducks: a solution for both economic and environmental challenges of small farmers. Livestock Research for Rural Development. Volume 36, Article #*1*. Retrieved January 31, 2025, from http://www.lrrd.org/lrrd36/1/3601bodi.html

[5]. Dörper A., Gort G., Harn J. V., Oonincx D. G. A. B., Dicke M., Veldkamp T. 2024. Performance, egg quality and organ traits of laying hens fed black soldier fly larvae products. Poultry Science. 103:104229. 1-13. https://doi.org/10.1016/j.psj.2024.104229

[6]. Gariglio M, Dabbou S, Biasato I et al 2019 Nutritional effects of the dietary inclusion of partially defatted *Hermetia illucens* larva meal in Muscovy duck. J Animal Sci Biotechnol 10, 37

[7]. Khan, M. N. Chand , S. Khan, S. Naz, A.F.Alrefaei, M. H. Almutairi, D. Sifa and R. U.Khan. 2023. Partial and total replacement of soybean meal with maggot larvae meal in broiler chicken diets: Impact on growth performance, nutrients digestibility, haemotological parameters and intestinal histomorphology. Livestock Science, 277.

[8]. Makkar, H. P. S., and Becker, K. 2009. Nutritional value of the larvae of the black soldier fly (Hermetia illucens) in poultry feeding. Journal of Insects as Food and Feed, *5*(2), 93-105.

[9]. Moniello, G., A. Ariano, V. Panettieri, F. Tulli, I. Olivotto, M. Messina, B. Randazzo, L. Severino, G. Piccolo, N. Musco, and et al. 2019. "Intestinal Morphometry, Enzymatic and Microbial Activity in Laying Hens Fed Different Levels of a *Hermetia illucens* Larvae Meal and Toxic Elements Content of the Insect Meal and Diets" Animals 9 (3): 86. https://doi.org/10.3390/ani9030086

[10]. Ogunji J O, Kloasw W, Wirth M, Schulz C, and Rennert B 2008 Housefly maggot meal (Magmeal) as a protein source for oreochromis niloticus (Linn.) Asian Fisheries Sci. 21:319-331

[11]. Prasetia K. W., Astawa I. P. A., dan Wirapartha M. 2023. Pengaruh Penggantian Ransum Komersil Dengan Tepung Maggot (*Hermetia ilucens*) Terhadap Performa Ayam Petelur. (The Effect of Replacing Commercial Feeds with Maggot Meal (Hermetia ilucens) on the Performance of Laying Hens). Jurnal Peternakan Tropika. 12(3); 444-456.

[12]. Raharja I. G. N. B. dan Astawa I. P. A. 2024. Pemanfaatan Maggot Black Soldier Sebagai Sumber Protein Terhadap Produktivitas Ayam Petelur Isa Brown. Majalah Ilmiah Peternakan. Utilization of Black Soldier Maggots as a Source of Protein on the Productivity of Isa Brown Laying Hens) Majalah Ilmiah Peternakan 27 (2); 71-78. DOI: https://doi.org/10.2483/MIP.2024.v27.i02.p03

[13]. SPSS (Statistical Package for Social Sciences) version 15.0, USA 2006. Comman Syntax Reference. 233, South Wacker Drive, Chicago

[14]. Schiavone A, Dabbou S, Petracci M, Zampiga M, Sirri F, Biasato I, Gai F, Gasco L. Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on carcass traits, breast meat quality and safety. Animal. 2019 Oct;13(10):2397-2405. doi: 10.1017/S1751731119000685.

[15]. Sheppard D C, Tomberlin J K, Joyce J A, Kiser B C and Sumner S M 2002 Rearing methods for the black soldier fly (*Diptera: Stratiomyidae*). J Med Entomol 39(4):695-8.

[16]. Sumiati, Purnamasari D. K., Erwan, Syamsuhaidi. Wiryawan K. G. Rizki A. N. A. Isnaini M. 2022. Penggunaan Maggot (*Hermetia illucens*) Dalam Pakan Ayam Ras Petelur. Jurnal Sains Teknologi & Lingkungan. 8 (1): 87 – 96.DOI:https://doi.org/10.29303/jstl.v8i1.340

[17]. Tahamtani, F.M. E. Ivarsson, V. Wiklicky, C. Lalander, Helena Wall, T. Bas Rodenburg , Frank A.M. Tuyttens , and Carlos E. Hernandez. 2019. Feeding live Black Soldier Fly larvae (*Hermetia illucens*) to laying hens: effects on feed consumption, hen health, hen behavior, and egg quality. Poultry Science 10 (1).

[18]. Teguia A and Beynen A C .2005. Alternative feedstuffs for broilers in Cameroon. *Livestock Research for Rural Development. Vol. 17, Art. #34.*Retrieved August 11, 2023