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Influence of black soldier fly larvae *(Hermetia illucens* L.*)* on the growth performance of broiler

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Abstract

To evaluate the performance of broilers fed diet with different levels of black soldier fly larvae meal (*Hermetia illucens* L.). A total of 150-day old broilers were divided to 5 groups and assigned to one of the 5 dietary treatments with 0, 3, 6, 9 and 12% black soldier fly larvae meal (BSFLM) following the Completely Randomized Design (CRD). The study was conducted at Watwat, Kasibu Nueva Vizcaya from January 15 to February 19, 2022 for 6 weeks in a full confinement system. Result of the study revealed that the different levels of black soldier fly larvae meal (BSFLM) (3, 6, 9 and 12%) have no positive effect on the growth performance of broilers. However, results shown that broilers fed diet with BSFLM is comparable to without BSFLM in terms of the body weight, gain in weight, feed consumption, percentage rate of growth, FCR, FCE, and dressing percentage. The addition of 12% BSFLM on the ration generated higher return Php 127.18, hence, recommended. Further research is needed to include the meat evaluation particularly on the breast and thigh muscles, and the use of commercial feeds to compare and obtain a more conclusive result.

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Introduction

Poultry species is the most progressive animal enterprise today. It is one of the world's major and fastest producers of meat. It provides an immense supply of food for the world's population, and it is not discouraged by the many religious taboos. Chicken is one of the very popular poultry species because they are efficient converter and good source of meat and eggs. Through different breeding researches, growth performance and productivity of chicken improved. Now a days, there are what we called broilers which refers to young chicks of either sex that can be marketed at 6-7 weeks of age specifically raised for meat production.

The advancement of technology greatly increases the production of broilers in the Philippines and the demand outlook appears to be positive. However, it faces many challenges including market instability, high input costs, inefficient marketing systems, and threats of imports. Also, the concerns of consumer for the use of antimicrobial growth promoters, animal protein, and genetically modified materials in feeds, food safety and product quality animal welfare and the environmental impact associated with industrialized poultry production (Chang, 2007). So that the Philippines will be at par with other countries Philippine broiler industry must strive for greater efficiency in production, lower input costs and efficient marketing system.

Major input in broiler production is feeds accounting 60-75% of the total production cost in an intensive rearing system (Chiba, 2014). The raw material usually used as a protein source in animal diets is fish meal and soybean which is too expensive resulting for our feeds to be costly. Therefore, the search for alternative sources of raw materials to formulate into feeds is essential to minimize feed cost. And in order to formulate feeds with good quality, it is necessary to know the different nutritional value of the different ingredients in basis of computing the feed requirement of the broiler.

One of the ways to reduce the cost of feeds in broiler production is making an alternative protein resource available at cheaper price. The most promising insect species to be used as feed for industrial feed production are black soldier flies, common housefly larvae, silkworms and yellow mealworms. Grasshoppers and termites are also viable, but to a lesser extent. The used of insect as source of protein for livestock, especially for poultry has been considered (Makkar *et al.*, 2014). This can be a sustainable cheaper alternative source of protein. Cullere *et al.* (2016) demonstrated that Black Soldier Fly Larvae Meal (BSFLM) can partially replace the conventional soybean meal in the diet of growing broilers.

There is lots of indigenous feedstuff that can be utilized as possible. Any use of it must not only be palatable, digestible and meet the same requirements for broilers but to have no any harmful physiological effect to the animal. Research for the effect black soldier fly larvae meal as alternative feedstuff is necessary for validation, possible decrease in feed cost and commercialization of a possible technology. Hence, this study generally was conducted to evaluate the influence of different levels of black soldier fly larvae meal on growth performance of broilers.

Materials and methods

The experimental house

A total of twelve (15) cages was prepared measuring 10 square feet per cage. The poultry house was constructed using locally available materials and each cage was installed with 50 watts incandescent bulb.

Procurement of birds

A total of one hundred twenty (150) Arbor Acre broiler chick was purchased from a reliable store in a nearby town.

Environment sanitation and hygiene

Before the arrival of the day-old chicks the poultry house and the premises were cleaned and disinfected thoroughly to prevent the occurrence of disease cause by harmful microorganism that might be present in

the premises. Chicken dungs were regularly removed from the experimental site to maintain cleanliness. Waterers were also washed every weekend to prevent any green algae.

Collection and preparation of black soldier fly larvae meal

Black soldier fly eggs were purchased through online and cultured until they multiply. Garbage of fruits and vegetables were collected from the market and chopped to pieces then fed to the larvae. *Trichanthera* leaves was also collected and chopped and fed to the larvae.

During the pupal stage of the BSF, some were collected and some were left to continue their life cycle. The collected pupae were toast and pulverized and mixed to other feed ingredients to make a home mixed ration appropriate for the broilers.

Experimental design and treatments

The Complete Randomize Design (CRD) was used with 5 dietary treatments (control and 4 levels of BSFLM). Each treatment was replicated three (3) times with ten (10) heads of broilers per replication.

The experimental treatments were as follows:

Treatment 1 - home-mixed ration (control)

Treatment 2 – home-mixed ration with 3% Black Soldier Fly Larvae Meal

Treatment 3 –home-mixed ration with 6% Black Soldier Fly Larvae Meal

Treatment 4 –home-mixed ration with 9% Black Soldier Fly Larvae Meal

Treatment 5 – home-mixed ration with 12% Black Soldier Fly Larvae Meal

Feeding management

A home-mixed ration was used through-out the study. The ingredients used were Soybean oil meal, Black soldier fly larvae meal, Fishmeal, Copra meal, RB D1, Sorghum, Corn yellow and other supplements.

The home-mixed ration was used for a period of time until it reaches 5 weeks of age. For the first week the feed was placed on an old newspaper. The rest of the experimental period was placed in a plastic feeder. Ad libitum feeding was practiced throughout the study.

Provision of drinking water

Clean and fresh drinking water was given at all times. It was changed two times a day, morning and afternoon or as needed.

Weighing of birds

Upon the arrival of the birds, the initial weight was taken and recorded. Weekly weighing was done during the entire observation period. During weighing period, the birds were weighed before feeding them in the morning.

Data gathered

The following data were gathered and recorded for analysis and evaluation:

Initial and weekly body weight: The initial body weight of the birds was taken after their arrival and before they were distributed to the experimental cages. Their body weight was taken weekly throughout the period of experiment.

Gain in weight

The gain in weight of the birds was taken by subtracting the initial weight from the final weight *Feed Consumption*. The feed consumption of the birds in the different treatments was taken into account. The feed consumed and left-over were subtracted from the feed offered to determine the actual feed consumption.

Feed conversion ratio and efficiency

The feed conversion ratio and efficiency of the bird was determined by using the Biddle and Juerguenson's formula which are follows:

Feed conversion ratio = Feed consumed/ Gain in weight

Feed conversion efficiency = {(Gain in weight)/(Feed consumed)} × 100

Dressing percentage (with and without giblets)

The live weight of the samples from each replication was recorded accordingly. For identification a tag corresponding to each treatment was placed on each shank. The dressing percentage with and without giblets was computed based on the following formula:

Dressing percentage without giblets = {(Dress weight)/(Live weight)} × 100

Liver and pancreas weight

The data on liver and pancreas weights were gathered and are a basis in determining possible toxin substances on the feed supplements.

Income over feed and chick costs

The Income above Feed and Chick Cost was computed at the end of the study by considering the value of chicken per head less the expenses of feeds in raising the chicken.

Statistical analysis

All the gathered data were collated, tabulated and analyzed using the Analysis of Variance following the Completely Randomized Design (CRD). The Least Significant Differences was used to compare significant result.

Results and discussion

Body weight

The body weight (g) of the broiler chicken fed with black soldier fly larvae meal (BSFLM) is presented in Table 1. No significant difference on the initial body weight of the broilers were observed. The initial body weight of the experimental broilers ranged from 190 to 193.83 grams. This indicates the uniformity of the experimental broilers which is essential in attaining reliable results.

It was noted that the final body weight of the broiler was comparable with each other with a mean value ranging from 1998.80 to 2157.50 grams. Although the results are not significant, highest body weight was obtained on Treatment 5, where broilers fed with 12% BSFLM and lowest are those broilers in Treatment 4 with 9% of BSFLM in the ration. This finding probably caused by the ability of the broiler to absorb nutrient through their gut morphology for better performance (Dabbou *et al.*, 2018; Baisato *et al.*, 2018).

In line with the results of this study, Schiavone *et al.* (2018) documented an increase in the body weight of broiler chickens given black soldier fly larvae meal. They further reported that the high carbohydrate, protein, fat, and iron content of black soldier fly larvae meal may contribute to this increase in body weight of poultry.

Thus, the supplementation of BSFLM up to 12% did not affect the growth performance of broilers in terms of their body weight. Additionally, the BSFLM have no detrimental effect and is safe as feed ingredients to broilers ration. Black soldier flies larvae meal being an insect-based ingredient is rich in key nutrients such as a crude protein with a high biological value, fat, and minerals (Makkar *et al.* 2014).

Gain in weight

The gain in weight (g) of the broiler chicken fed with black soldier fly larvae meal (BSFLM) is presented in Table 1. The results revealed no significant differences the total gain in weight of the experimental broiler fed with different levels of BSFLM obtained a mean value ranging 1439.33 to 1563.67 grams.

However, the pattern of differences from first week to third week of the study showed a generally decreasing trend in the gain in weight but on the fourth up to end of the study an increase in gain in weight was observed. The decrease in the gain in weight of broilers that were fed BSFP could be attributed to the chitin content, which increases with the insect's age and, hence, decreases protein digestibility (Bovera *et al.*, 2015; Marono *et al.*, 2017).

Feed consumption

The feed consumption (g) of the broiler chicken fed with black soldier fly larvae meal (BSFLM) is presented in Table 1.

Table 1. Growth performance of broilers fed with different levels of black soldier fly meal

Treatments	Initial BW	Final BW	Gain in weight	Feed consumption	Feed conversion ratio	Feed conversion efficiency
T1	192.33	2076.76	1439.33	3987.21	2.12	47.26
T2	190.16	2021.83	1439.83	4009.97	2.20	45.78
T3	190.83	2006.67	1428.67	3923.27	2.15	46.56
T4	193.83	1998.80	1452.33	3941.44	2.20	45.70
T5	190.50	2157.50	1563.67	4027.44	2.06	48.90
ANOVA	ns	ns	ns	ns	ns	ns
C.V. (%)	0.32	6.60	6.15	1.98	8.48	8.32

ns-not significant

In terms of the cumulative feed consumption of the broiler, no significant differences were observed among treatment with a mean value ranging from 3923.27 to 4027.44 grams. Broilers in Treatment 5 fed with 12% BSFLM got the highest feed consumption among all the treatments while the lowest was observed on the broilers in Treatment 3 with 6% of BSFLM. The use of black soldier fly larvae meal was also reported to increase feed consumption by the broilers in Treatment 5. It is not known for certain the reason why the black soldier fly larvae meal can increase feed consumption in the broiler chickens, but the glutamic acid content in the black soldier fly larvae meal was very likely to increase the flavor of feeds, thereby increasing the appetite of chickens (Fitriana *et al.*, 2022). However, there was a noticeable decrease in the feed intake of birds with successive increases in BSFLM in the diets. This may be attributed to high-fat content as a result of increased levels of BSFLM (Sumbule *et al.,* 2021) with high fat (44.84%). This was translated to the diet, consequently increasing dietary energy density and thereby decreasing feed intake. This could be because the birds in T3 and T4 took time to fully adapt to the diets, while the birds in T1 did not need to adapt to a diet that is comparable to a commercial broiler feed and this is supported by Veldkamp *et al.*, 2005. However, despite a decrease in feed intake with increased levels of BSFLM in the diets, there was an increase in gain in weight among the birds. This was due to an adequate supply of nutrients to the birds provided by the various diet types (Sumbule *et al.,* 2021).

Feed conversion ratio and efficiency

The feed conversion ratio and efficiency of the broiler chicken fed with black soldier fly larvae meal (BSFLM) is presented in Table 1. Feed conversion ratio is the ratio between the total feed consumed over the total weight gain of the broilers. The lower the value, the more efficient are the broilers in converting feeds to live weight. Based on the result of the study, the data shows that all the different treatments have statistically the same amount of feed consumed to produce a kilogram of weight with an average ratio of 2.06 to 2.20. Although the results are not significant, data revealed that broilers in Treatment 5 with 12% BSFLM had lowest average feed conversion ratio and highest FCR was observed in Treatments 2 and 4 with 3% and 9% BSFLM, respectively. Similar results were found in previous research, where the inclusion of BSF larvae meal (Dabbou *et al.*, 2018; Mutisya *et al.*, 2021; Machado *et al.*, 2023) or BSF larvae oil (Schiavone *et al.*, 2018; Dabbou *et al.*, 2021; Schäfer *et al.*, 2023) in broiler diets did not significantly affect their FCR, while the combination of both products in the diet was found to improve broiler FCR. In this study, dietary inclusion of black soldier fly larvae meal up to 12% in feed decreased FCR value of the chickens. This may indicate that feeding black soldier fly larvae meal had no detrimental effect on the digestibility of the broiler chickens. The finding was therefore in contrast to Nasution *et al.* (2020) documenting the adverse effect of feeding black soldier fly larvae meal on the nutrient digestibility of broilers due to the presence of chitin (anti-nutrient compound).

Another study in quail found that feeding black soldier fly larvae meal increased daily gain, daily feed intake, but had no effect feed conversion ratio (FCR). Likewise, dietary inclusion of black soldier fly larvae meal increased dry matter content of quail meat (Nguyen *et al.*, 2023).

Table 2. Dressing percentage, liver and pancreas weight of broiler

Treatments	Dressing percentage with giblets	Dressing percentage without giblets	Liver weight	Pancreas weight
T1	76.34	71.80	41.07	4.40
T2	74.90	70.39	41.82	4.40
T3	77.99	73.20	44.40	4.43
T4	73.37	68.50	48.27	4.37
T5	79.93	74.93	45.30	5.48
ANOVA	ns	ns	ns	ns
C.V. (%)	1.30	4.96	21.40	15.75

ns-not significant

Table 3. Income over feed and chick costs

ITEMS	T1	T2	T3	T4	T5
Final weight	2.08	2.02	2.01	2.00	2.158
Return per broiler[1]	311.51	303.28	301.00	299.82	323.63
Cost of chick per head	45	45	45	45	45
Feed consumed per bird (Starter)	1.87	1.88	1.84	1.89	1.85
Feed consumed per bird (Finisher)	2.11	2.13	2.08	2.06	2.18
Price of feeds per kilogram (Starter)[2]	37.90	37.97	37.84	37.90	37.62
Price of feeds per kilogram (Finisher)[2]	37.78	37.61	37.88	37.72	37.59
Cost of feed consumed (Starter)	70.97	71.26	69.81	71.45	69.60
Cost of feed consumed (Finisher)	79.88	80.22	78.73	77.54	81.84
Total expenses	195.85	196.48	193.54	194.00	196.45
Net return	115.66	106.79	107.46	105.82	127.18

[1]Computed based from the prevailing market price of broiler at 150Php per kilogram live weight

[2]Computed based from the price per kilogram of formulated feeds

In addition, Dabbou *et al.* (2018), found no change in the FCRs of broilers fed diets comprising 5% and 10% BSFL but an impaired FCR in the diet containing 15% compared to the control diet (0%).

The same trend was observed in terms of feed conversion efficiency of broilers supplemented with and without BSFLM. Based on the result of the study, the broilers have an average efficiency means of 45.70 to 48.90%.

However, the previous studies point out that the effect of BSFLM on feed utilization depends on the poultry species and inclusion level. Also, these results suggest that the protein and amino acid contents of BSFLM are as biologically valuable as those of SBM and FM. The present results also concur with Spranghers *et al.* (2017) and Kim *et al.* (2020) who observed that BSFLM's high crude protein and fat content made them an excellent source and valuable component of animal feed nutrition.

Dressing percentage, liver and pancreas weights

Table 2 shows the dressing percentage with and without giblets, liver, and pancreas weights of the broiler chicken. Although the results are not significant, statistically, 79.93% and 74.93% and in Treatment 5 with 12% BSFLM showed a higher dressing percentage in with and without giblets that conforms to the final weight and weekly gain in weight. Similar results were found on a study conducted by Cockcroft (2018) where broilers were supplemented with BSF larvae meal in different preparations (full fat, dry rendered, extruded). She disclosed that the dressing percentage parameter of the chickens has no significant difference between treatments.

No significant result was revealed in terms of liver weight and pancreas weight. The average means of the liver ranges from 41.07 to 48.27 grams. These findings are slightly in close range to the findings of Ishi *et al.* (2000), who observed that the liver of a broiler was weighing between 40 to 60 grams.

However, Iqbal *et al.* (2014) have also reported a mean weight of fresh liver from broiler of 47.98g at the sixth week of the study. Likewise, the pancreas weight revealed no significant result with a mean value of 4.37 to 5.48 grams. This observation indicates that the formulated ration with different levels of BSFLM is safe to use without any adverse effect on the broiler's performance.

Income over feed and chick costs

The income over feed and chick costs is presented in Table 3. The income was computed based on the final weight of the Broiler multiplied by the prevailing price. In descending order, the return above feed cost from the different treatments is as follows: T_5 = PhP 127.18, T_1 = PhP 115.66, T_2 = 106.79, T_3= 107.46 and T_4 = PhP 105.82. The computed income derived from broilers fed with varying levels of black soldier fly larvae meal can possibly reduce feed cost this agrees with the report of Khan *et al.*, 2016; Van Huis *et al.*, 2013 that the use of insect meal can lower the cost of poultry feeds.

Conclusion

Result of the study revealed that the different levels of black soldier fly larvae meal (BSFLM) (3, 6, 9 and 12%) have no positive effect on the growth performance of broilers. However, results shown that broilers fed diet with BSFLM is comparable to without BSFLM in terms of the body weight, gain in weight, feed consumption, FCR, FCE, and dressing percentage. In terms of feed cost the addition of 12% BSFLM on the ration generated higher return with Php 127.18, hence recommended. Further research is also recommended for the formulation to be pelletized to improve feeding efficiency of the chickens, and to compare the result with commercially available feeds.

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