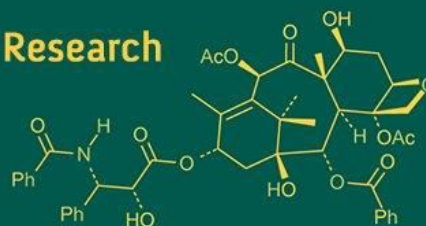


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Effect of feeding black soldier fly larvae meal on carcass characteristics, physico-chemical attributes and protein solubility in commercial broilers

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Abstract

Insects could be considered as a potential and sustainable cheaper alternative source of protein to replace soybean partially in livestock feed, especially poultry due to fact that they contain similar composition as that of soya bean or fish meal (Fat: 30-40% dry matter and protein: 40-60% DM) and its ubiquitous nature. An attempt was made to incorporate and evaluate the effect of inclusion of black Soldier fly larvae meal in broiler diet on carcass characteristics etc. Birds up to 6 weeks were fed diet with 5, 10 and 15 percent of black soldier fly larvae meal and all the diets will be formulated to meet isocaloric and nitrogenous by manipulating the diet inclusion level in the basal diet. At the end of the 6th week, birds were slaughtered and evaluated for the carcass characteristics physico-chemical attributes and protein solubility. The inclusion of 10 percent BSF meal significantly increased the live weight, carcass weight, dressing percentage, breast yield etc. However, no significant differences could be observed in recorded percent neck yield, back yield, wing yield, thigh yield, drumstick yield recorded between all the four treatment groups. Inclusion of BSF larvae meal at different levels did not have any significant effect on pH at 45 minutes and ultimate pH at 24 hours. No significant difference in cooking loss, water holding capacity and drip loss was observed in the present study between the different treatments.

Keywords: Black soldier fly larvae meal, carcass, physico-chemical attributes, broiler

Introduction

It has been estimated that approximately 35 percent of global crop production is being utilized as feed to produce various livestock products viz., milk, meat, egg and other animal based products (Foley *et al.*, 2011) ^[11]. The increasing global demand for poultry meat has led to challenges especially with respect to availability of quality and sufficient quantity protein such as soybean and fish meal for inclusion in broiler diets. In this context, insects could be considered as a potential and sustainable cheaper alternative source of protein to replace soybean partially in livestock feed, especially poultry due to fact that they contain similar composition as that of soya bean or fish meal (Fat: 30-40% dry matter and protein: 40-60% DM) and its ubiquitous nature (Makkar *et al.*, 2014; Elahi *et al.*, 2022) ^[19, 10]. Among the different insects utilized in poultry feed, black soldier fly (BSF) larvae and its meal (*Hermetia illucens* L) has been widely used as an ingredient because of its richness in fat (7-39% DM), protein (37-63% DM) and having a better amino acid profile as compared to soybean meal (Barragan-Fonseca *et al.*, 2019) ^[3]. An attempt was made to incorporate and evaluate the effect of inclusion of balck Soldier fly larvae meal in broiler diet on carcass characteristics, physico-chemical attributes and protein solubility of commercial broilers.

Materials and Methods

A total of one hundred and twenty (120) day old commercial broiler chicks were procured from Venkateshwara Hatcheries Pvt. Ltd. Bengaluru and all the chicks were weighed and wing banded individually. The study was carried out with permission from Institutional Animal Ethics Committee, Veterinary College, Hebbal, Bangalore. The chicks were allocated to four different treatment groups each consisting of three replicates with 10 chicks each (30 chicks per treatment).

Each of the treatment groups were fed with different types of experimental diets. The control group T₁ was fed with soybean meal based basal diet as per BIS (2007) standards. Black Soldier Fly Larvae meal was procured from Sri Kalleshwari feeds Pvt Ltd, Kerala. The composition of BSF larvae meal is Metabolizable energy (kcal/kg): 3970.1, Crude protein (%):59.7, Calcium (%): 2.3, Phosphorus (%): 1.6, Lysine (g/100 g): 2.8, Methionine (g/100 g): 1.0. Birds in treatment groups T₂, T₃, T₄ were fed diet with 5, 10 and 15 percent of black soldier fly larvae meal respectively and all the diets will be formulated to meet isocaloric and nitrogenous by manipulating the diet inclusion level in the basal diet as per Chidanandaiah *et al.*, 2026 [6]. The chicks were reared in deep litter system and maintained under standard managerial practices till 6th weeks of age. Feed and water was provided *ad libitum* throughout the experimental period. At the end of the 6th week, six (6) birds from each treatment were slaughtered as per standard protocol to evaluate the carcass characteristics (dressing percentage, yield of edible offals, yield of cut up parts), physico-chemical attributes [pH_{45min}, pH_{24hrs}, Drip loss%, Cooking loss (%), Water holding capacity (%), Rigor value (24hrs)] and protein solubility [Sarcoplasmic Protein (mg/g), Myofibrillar Protein (mg/g) and Total Protein (mg/g)]

The dressing percentage was calculated on the basis of hot carcass weight (HCW) and pre-slaughter weight (PSW) using the formula:

Dressing percent = (Hot carcass weight/Pre slaughter weight) x 100

The pH of breast muscles was estimated after 45min and 24hrs of slaughter using a digital pH meter (Labman, LMPH-10, India) as described by Naveena *et al.* (2004) [22]. Water holding capacity (WHC) was determined according to the protocol of Wardlaw *et al.* (2006) [31]. Drip loss was calculated and expressed as the percentage of the initial weight (Remignon *et al.*, 1996) [26]. The percent cooking loss was determined by weight loss after cooking of meat for 1 h in water bath at 80 °C (Babiker *et al.*, 1990) [2].

Cooking loss (%) = (Weight of cooked meat/Weight of raw meat) × 100.

Protein extractability was determined according to the procedure given by Joo *et al.* (1999) [14].

Statistical analysis

The descriptive statistics for the different types of data were determined as per Snedecor and Cochran (1994) [29] and the SPSS 20 statistical software. The differences between the mean values were evaluated using Tukey's Range Test at a significance level of 0.05 ($p \leq 0.05$).

Results and Discussion

Carcass characteristics: The data on effect of feeding Black soldier fly larvae meal on carcass characteristics were presented in Table 1. It was evident that T₂ (5%) and T₃ (10%) had significantly ($p < 0.05$) higher body weight among the groups with no significant difference between them and in similar way control (T₁) and T₄ did not differ significantly. The findings of the present results were in agreement with Dabbou *et al.* (2018) [8] who observed that the inclusion of Black soldier fly larvae meal had a

significant ($p < 0.05$) effect on body weight at 6th week of age in broilers. Similarly, Moula *et al.* (2018) [20] also found an improvement in Ardennaise chicken fed with 8 percent Black soldier fly larvae meal. The increase in body weight at 5 and 10 percent inclusion level in this study may be attributed to higher nutrient content, higher palatability and beneficial changes in gut morphology and gut microflora which in turn would have resulted in better digestion and absorption (Dabbou *et al.*, 2018) [8]. The lower body weight gain in 15 percent inclusion level in this study may be attributed to the increasing level of chitin which is a component of the exoskeleton of the larvae which might have hindered digestion as well as absorption of the nutrients. The Mean $\pm$ SE of carcass weight of commercial broilers of T₁, T₂, T₃ and T₄ were 1431 $\pm$ 15.57, 1498 $\pm$ 31.38, 1530 $\pm$ 15.74 and 1424 $\pm$ 20.55, respectively. The Mean $\pm$ SE of dressing percentage in groups T₁, T₂, T₃ and T₄ were 67.94 $\pm$ 1.036, 73.15 $\pm$ 0.584, 73.42 $\pm$ 1.440 and 67.16 $\pm$ 1.567, respectively. The Mean $\pm$ SE of breast yield of commercial broilers in T₁, T₂, T₃ and T₄ were 24.14 $\pm$ 0.27, 25.35 $\pm$ 0.24, 25.46 $\pm$ 0.34 and 24.04 $\pm$ 0.21, respectively. The treatment group T₂ and T₃ showed significantly ($p < 0.05$) higher dressing percentage and breast yield than T₁ and T₄. The results of this study are in concurrence with the findings of Raju *et al.* (2023) [25] who observed that graded levels of Black soldier fly larva meal (0, 5, 7.5 and 10%) inclusion resulted in increased dressing yield, breast weight, and abdominal fat content with higher levels of BSF larvae meal in the diet. Longvah *et al.* (2011) [16] also opined that higher levels of inclusion of silk worm pupae and pre pupae meal in broiler diets resulted in a significant decrease in carcass weight and they attributed this to the level of chitin present in the exoskeleton of the meal. In similar lines, Gasco *et al.* (2023) [12] reported that the broiler birds that were fed with black soldier fly larvae meal exhibited higher dressing percentage and higher breast yield compared to that of control. It was observed that BSF larvae meal inclusion at 5 percent resulted in higher carcass weight and breast meat yield as compared to higher (15%) levels of inclusion (Popova *et al.*, 2020) [24]. The researchers have opined that BSF larvae meal inclusion at optimal levels resulted in better carcass yield and meat quality. However, no significant differences could be observed in percent neck yield, back yield, wing yield, thigh yield, drumstick yield recorded between all the four treatment groups. However, no negative impact on carcass weight, dressing percent and different cuts in broilers due to replacement of soybean meal by BSF larvae meal has been reported by Murawska *et al.* (2021) [21] in broiler (50, 70 and 100% substitution), Cullere *et al.* (2016) [7] in broiler (10 and 15%), Schiavone *et al.* (2019) [27] in broiler (up to 15%), Altmann *et al.* (2018) [1] in broilers fed insect meal (50%), Loponte *et al.* (2017) [17] in Barbary partridge (25 to 50%), Dahiru *et al.* (2016) [1] in spring chicken (5, 7.5 and 10%), Heita *et al.* (2023) [13] in broilers (10%). Overall, the results verify that insect meals contain sufficient nutrients for broiler production. These studies have clearly indicated that BSF larvae meal could be used as a cost effective and sustainable alternative to conventional feed sources such as soyabean meal without much adverse effect on the carcass and yield of different cuts in broilers.

Physico-chemical attributes: The Mean $\pm$ SE of pH_{45min}, pH_{24hrs}, drip loss, cooking loss, water holding capacity and

rigor value of breast meat from commercial broilers fed different levels of Black soldier fly larvae meal are presented in the Table 2. pH is one of the key factors influencing the quality of the meat which governs several physico-chemical properties of meat such as water holding capacity, colour, shear force and tenderness (Ma *et al.*, 2019) [18]. In the present study, it was observed that inclusion of BSF larvae meal at different levels did not have any significant effect on pH at 45 minutes and ultimate pH at 24 hours. The pH_{45mins} in this study ranged from 6.11 to 5.95 and the pH_{24hrs} (ultimate pH) ranged from 5.53 to 5.61 in all the treatment groups. The results are in accordance with Van Laack *et al.* (2000) [30] who reported that the normal broiler breast meat ultimate pH was 5.56 to 5.75. Similar to our results Schiavone *et al.* (2019) [27] reported that the ultimate pH of the breast muscle ranged from 5.98-6.03 at different level of inclusion of BSF larvae meal up to 15 percent. However, contrary to the findings of our study Bovera *et al.* (2016) [5] and Murawska *et al.* (2021) [21] observed a significant increase in pH of the breast muscle in broilers fed 70 percent BSF larvae meal and diet supplemented with *Tenebrio molitor* larvae meal in broilers. No significant difference in cooking loss, water holding capacity and drip loss was observed in the present study between the different treatments. Our findings corroborate with the results of Kim *et al.* (2021) [15] who reported that replacing soybean meal with BSF larvae meal at 25 and 50 percent did not cause any changes in cooking loss and drip loss. No statistically significant effect on cooking losses was observed in partridges fed BSF (*Hermetia illucens*) and *Tenebrio molitor* larvae meal (Secci *et al.*, 2018) [28]. In

similar lines, Pieterse *et al.* (2019) [23] observed that inclusion of BSF larvae meal up to 15 percent did not cause any significant variations in pH at 45 minutes, pH at 24 hours, cooking loss, thaw loss and water holding capacity of the meat.

Protein solubility: The Mean $\pm$ SE of Sarcoplasmic Protein (mg/g), Myofibrillar Protein (mg/g) and Total Protein (mg/g) values of breast meat from commercial broilers fed with Black soldier fly larvae meal are presented in the Table 3. The Mean $\pm$ SE of the Sarcoplasmic Protein of breast meat in T₁, T₂, T₃ and T₄ were 56.4 $\pm$ 0.38, 57.79 $\pm$ 0.45, 58.90 $\pm$ 0.55 and 56.47 $\pm$ 1.61 respectively. No significant differences in Sarcoplasmic protein were recorded between all four treatments. However, highest Sarcoplasmic Protein was observed in T₃ among all the treatments. The Mean $\pm$ SE of the Myofibrillar Protein of breast meat in T₁, T₂, T₃ and T₄ were 74.05 $\pm$ 0.89, 75.56 $\pm$ 1.5, 75.83 $\pm$ 1.7 and 73.57 $\pm$ 0.91 respectively. No significant differences in Myofibrillar protein were recorded between all four treatments. The Mean $\pm$ SE of the Total Protein of breast meat in T₁, T₂, T₃ and T₄ were 130.49 $\pm$ 1.07, 133.36 $\pm$ 1.2, 134.73 $\pm$ 1.6 and 130.04 $\pm$ 1.9 respectively. No significant differences in Total Protein were recorded between all four treatments. No significant difference could be observed with respect to solubility of sarcoplasmic, myofibrillar and total protein in breast muscle between different treatments. However, no literatures are available with respect to inclusion of insect meal and its effect on protein solubility in broilers or other poultry species to compare with the results of this study.

Table 1: Effect of feeding Black soldier fly larvae (BSF) meal on carcass characteristics (Mean $\pm$ SE) in commercial broilers

TRAITS	T ₁	T ₂	T ₃	T ₄
Live weight (g)	2068 $\pm$ 16.11 ^b	2168 $\pm$ 25.02 ^a	2170 $\pm$ 9.68 ^a	2090 $\pm$ 23.49 ^b
Carcass weight (g)	1431 $\pm$ 15.57 ^b	1498 $\pm$ 31.38 ^{ab}	1530 $\pm$ 15.74 ^a	1424 $\pm$ 20.55 ^b
Dressing percentage (%)	67.94 $\pm$ 1.04 ^b	73.15 $\pm$ 0.58 ^a	73.24 $\pm$ 1.44 ^a	67.16 $\pm$ 1.56 ^b
Breast yield (%)	24.14 $\pm$ 0.27 ^b	25.35 $\pm$ 0.24 ^a	25.46 $\pm$ 0.34 ^a	24.04 $\pm$ 0.21 ^b
Neck yield (%)	5.25 $\pm$ 0.09	5.53 $\pm$ 0.08	5.42 $\pm$ 0.09	5.30 $\pm$ 0.08
Back yield (%)	21.83 $\pm$ 0.19	21.50 $\pm$ 0.32	21.92 $\pm$ 0.32	22.26 $\pm$ 0.37
Wing yield (%)	10.66 $\pm$ 0.17	10.88 $\pm$ 0.45	11.42 $\pm$ 0.40	10.74 $\pm$ 0.17
Thigh yield (%)	17.61 $\pm$ 0.15	17.42 $\pm$ 0.33	17.37 $\pm$ 0.28	17.61 $\pm$ 0.24
Drumstick yield (%)	16.58 $\pm$ 0.23	16.83 $\pm$ 0.22	16.84 $\pm$ 0.28	17.08 $\pm$ 0.18

Means bearing different superscripts (a, b, c) between the columns differ significantly ($p < 0.05$)

T₁ represents control (Basal diet), T₂ represents (5% BSF larvae meal inclusion), T₃ represents (10% BSF larvae meal inclusion) and T₄ represents (15% BSF larvae meal inclusion).

Table 2: Effect of feeding Black soldier fly larvae meal on physico-chemical attributes in (Mean $\pm$ SE) in commercial broilers

Parameters	T ₁	T ₂	T ₃	T ₄
pH _{45min}	5.95 $\pm$ 0.10	6.04 $\pm$ 0.11	6.11 $\pm$ 0.10	5.97 $\pm$ 0.14
pH _{24hrs}	5.56 $\pm$ 0.15	5.53 $\pm$ 0.04	5.61 $\pm$ 0.04	5.53 $\pm$ 0.03
Drip loss%	1.51 $\pm$ 0.03	1.43 $\pm$ 0.04	1.58 $\pm$ 0.03	1.56 $\pm$ 0.02
Cooking loss (%)	20.22 $\pm$ 0.31	19.43 $\pm$ 0.23	20.16 $\pm$ 0.55	20.02 $\pm$ 0.46
Water holding capacity (%)	10.39 $\pm$ 0.27	10.37 $\pm$ 0.07	10.63 $\pm$ 0.07	10.79 $\pm$ 0.18
Rigor value (24hrs)	0.5008 $\pm$ 0.03 ^b	0.6015 $\pm$ 0.02 ^a	0.6535 $\pm$ 0.03 ^a	0.6627 $\pm$ 0.02 ^a

Means bearing different superscripts (a, b, c) between the columns differ significantly ($p < 0.05$)

T₁ represents control (Basal diet), T₂ represents (5% BSF larvae meal inclusion), T₃ represents (10% BSF larvae meal inclusion) and T₄ represents (15% BSF larvae meal inclusion).

Table 3: Effect of feeding Black soldier fly larvae meal on protein solubility in commercial broilers

Parameters	T ₁	T ₂	T ₃	T ₄
Sarcoplasmic Protein (mg/g)	56.4 $\pm$ 0.38	57.79 $\pm$ 0.45	58.90 $\pm$ 0.55	56.47 $\pm$ 1.61
Myofibrillar Protein (mg/g)	74.05 $\pm$ 0.89	75.56 $\pm$ 1.5	75.83 $\pm$ 1.7	73.57 $\pm$ 0.91
Total Protein (mg/g)	130.49 $\pm$ 1.07	133.36 $\pm$ 1.2	134.73 $\pm$ 1.6	130.04 $\pm$ 1.9

T₁ represents control (Basal diet), T₂ represents (5% BSF larvae meal inclusion), T₃ represents (10% BSF larvae meal inclusion) and T₄ represents (15% BSF larvae meal inclusion).

Conclusion

Feeding Black soldier fly larvae meal at level of 5% (T₂) and 10% (T₃) had significantly ($p < 0.05$) improved the body weight, dressing percentage and breast yield. The increase in body weight at 5 and 10 percent inclusion level in this study may be attributed to higher nutrient content, higher palatability and beneficial changes in gut morphology and gut microflora which in turn would have resulted in better digestion and absorption. However, no negative impact on carcass weight, dressing percent and different cuts in broilers due to replacement of soybean meal by BSF larvae meal. Feeding Black soldier fly larvae meal had no significant difference in cooking loss, water holding capacity and drip loss between the different treatments. However, highest Sarcoplasmic Protein was observed in T₃ (at 10% level) among all the treatments.

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