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The potential effect of dietary inclusion of defatted black soldier fly meal on the quality and characteristics of cobb chicken meat

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ABSTRACT

Recently, substitution of poultry feed ingredient by using insect meals, has been a new trial focus; so, the objective of the present trial is to determine the optimal inclusion level and assess the effects of black soldier fly (BSF; Hermetia illucens) larvae meal Amin MAG® on carcass traits, meat quality parameters, and the caecum microbiota in broiler chicken. A total 144 one-day-old cobb chicks were randomly distributed into 4 dietary treatments, designed as follows: G1 (control group fed basal diet), G2 (group contains 6% BSF), G3 (group contains 12% BSF), and G4 (group contains 15% BSF). All the treated groups were subjected to the same management factors. At the end of the experimental trial on day 35, The broilers were slaughtered, dressed, and weighted (4 birds per group). Our results showed that the inclusion of BSF in cobb diets had no detrimental impact on carcass traits (relative weights of liver, heart, spleen, thymus, gizzard, and abdominal fat), return parameters from carcass and meat quality except tenderness decreased significantly in G2 and G3 compared to the control group and G4 , and BSF displays anti-oxidant effects with a significant decrease in malondialdehyde (MDA) with an increase in BSF in the diet . BSF didn't affect normal inhabitant bacteria of the intestine, such as lactobacillus and total bacterial count nor did it increase pathogenic bacteria, such as salmonella. In conclusion, adding BSF to cobb diets had no adverse effect on the meat quality parameter or gut health.

1. INTRODUCTION

By 2050, there will be 9 billion people, which will raise the world's demand for meat by 58% over what it was in 2010 (FAO, 2013). This will have an impact on the demand for livestock feeds and will put great pressure on the already scarce supplies (Van Huis, 2013). As a result, there is an urgent need for alternate protein sources for animals (Adeniji, 2007).Insects act as a viable substitutive nutrient source for the livestock industry that could help to address the rising demand and cost for traditional feedstuffs in a more sustainable manner (Cullere *et al.,* 2016). BSF larvae are potentially low-cost nutrient-rich alternative protein source for broilers because they have an adequate level of micro- and macronutrients (such as protein, fat, minerals, vitamins, and fibers). It has ability to produce high-quality protein from organic waste, control some undesirable bacteria and insect pests, give prospective chemical precursors for the production biodiesel and serve as feed for several kinds of animals (poultry, pigs and fish) (Barragan-Fonseca *et al.*, 2017) and (Makkar *et al.*, 2014). Insect feeds may contribute not only to improved productivity but also low feed costs, which may reduce the cost of eggs and poultry meat (Abro *et al.*, 2020). It is more cost-effective to use insect meals in animal diets than it is to use traditional components in poultry diets (Onsongo *et al.*, 2018). Also, Khan *et al.* (2016) reported that using insect meal can reduce the cost of poultry feed. Marono *et al.* (2017) demonstrated that defatted Hermetia illucens (HI) larva meal could also improve laying hens' feed efficiency.Carcass traits are essential factors in determining commercial portion yields, and the inclusion of BSF pre-pupae meal at different dietary levels (up to 15%) had no change on the carcass characteristics (Pieterse *et al.*, 2019). According to Kareem *et al.* (2018), there is no correlation between the breast production of chickens and increasing dietary BSF (up to 10%). The negative impact on the yield of carcasses and parts may be caused by the chitin in BSF larvae, which is indigestible by monogastric animals (Sánchez-Muros *et al.*, 2014) and can have a deleterious impact on protein digestibility (Longvah *et al.*, 2011a) and, as a result, affect the development of muscle and protein deposition in chickens. So, the study's objective was to investigate the influence of inclusion of BSF on carcass traits, meat quality parameters (drip loss at 24 and 48 hours, cooking loss, WHC, tenderness, PH, meat colour (a*, b*, L*), chroma, hue angel, and MDA), and the caecum microbiota in broiler chicken.

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2. MATERIAL AND METHODS

This trail was conducted at the Centre of Experimental Animal Research at the Faculty of Veterinary Medicine, Benha University, Egypt. Ethical approval for the study was obtained under the number (BUFVTM:12-03-23).

2.1. Birds and diets

144 healthy one-day-old broiler chicks (Cobb 500) (36 chicks per group, triplicated design, 12 birds per replicate) were reared for 35 days. All the chicks were deal with the same environmental, sanitary, and housing factors. The diets were formulated to contain 0%, 6%, 12%, and 15% de-fatted BSF meal (Amin MAG®) for G1, G2, G3, and G4, respectively (Table 1.) . Amin MAG® (100% de-fatted BSF meal) was purchased from the EGY MAG Biotechnology company. The feeding regime was in three stages: starter (days 0–10), grower (from days 11–22), and finisher (days 23–35).

2.2. Measurement of carcass traits parameters

By day 35 of the trial, four birds per group were randomly selected from each group, fasted for 12 hours, given free access to water, slaughtered, and weighed individually (pre- and post-slaughter weights). According to (Biesek *et al.* (2020) and (Wu *et al.* (2020), dressing % and relative internal organ weights were computed.

2.3. Measurement of Meat Quality of Breast Meat

Breast meats were used to assess meat quality (drip loss at 24 and 48 hours, cooking loss, water holding capacity (WHC), tenderness, PH, meat colour (a*, b*, L*), chroma, hue angel, and Malondialdehyde (MDA). According to (Kim *et al.* (2020) The WHC, cooking loss was calculated. The pH and shear force were estimated according to the methods described by (Kim *et al.*, 2021). According to the method of (Karatas *et al.*, 2002) MDA was measured. Determination of meat colour using the method of (Commission TI, 1977).

2.4. Evaluation of cecal microbiota

For microbial investigation, 3 samples per group removed from cecum at 35 days of age as described by (Sugiharto, 2016). Media used for microbial evaluation; Plate count agar (total aerobes) (Maturin and Peeler, 2001), salmonella shigella agar (salmonella) (Maddocks *et al.,* 2002) and MRS agar (Lactobacillus) (Ashraf and Shah 2011).

2.5. Statistical analysis

The statistical application SPSS (version 21 for Windows) (SPSS, 2012) was used to evaluate the data, which was analyzed with a one-way ANOVA followed by Tukey's test to determine the significance. In cases of lack of normality, the data were analyzed by Kruskal Wallis.

Table (1) ingredients% and chemical composition of experimental diets

	Starter ration				Grower ration				Finisher ration			
Ingredients %	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4
Yellow corn	53.06	57.91	58.23	57.93	61.86	63.01	63.15	64.42	61.97	61.76	62.72	62.5
Soybean meal 46	30.8	22.8	21.1	17.6	22.7	19.3	15.6	12	21.7	17.3	15.8	11.4
Defatted BSF (Amin MAG)	0	6	12	15	0	6	12	15	0	6	12	15
Corn gluten meal	5.5	5.5	1.14	0.57	6.5	3.4	0.5	0.1	7	4.4	0.1	0.05
Wheat Bran	3.4	2.4	2.4	3.9	2	2	2	2.5	1	2.5	1.9	3.7
Vegetable oil	2.4	0.85	1.03	1.06	2.5	2.3	2.5	2.5	4.3	4.4	4.4	4.4
Di calcium phosphate	2.25	2.02	1.74	1.58	1.89	1.6	1.34	1.2	1.8	1.5	1.2	1.1
Limestone	1	0.8	0.6	0.52	0.85	0.65	1.1	0.4	0.8	0.62	0.43	0.34
L_Lysine	0.37	0.48	0.44	0.48	0.46	0.46	0.46	0.5	0.32	0.34	0.28	0.34
Vit & min premix1	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sodium bicarbonate	0.29	0.28	0.28	0.28	0.34	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Sodium chloride	0.25	0.23	0.23	0.23	0.17	0.23	0.23	0.23	0.23	0.23	0.23	0.23
DL-Methionine	0.15	0.18	0.24	0.27	0.16	0.19	0.24	0.26	0.11	0.15	0.13	0.13
Choline chloride	0.12	0.15	0.15	0.16	0.13	0.14	0.15	0.15	0.11	0.13	0.15	0.15
L_Threonine	0.06	0.08	0.08	0.08	0.09	0.09	0.09	0.1	0.03	0.04	0.03	0.04
Antimycotoxin	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Antioxidants	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Royal Linco premix	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Protease enzyme	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chemical composition (%)												
	G1			G2			G3			G4		
	Starter	Grower	Finisher	Starter	Grower	Finisher	Starter	Grower	Finisher	Starter	Grower	Finisher
Crude protein	22	20	19	22	20	19	22	20	19	22	20	19
Crude fiber	2.42	2.21	2.14	3.25	3.09	3.05	4.25	4.08	4.03	4.80	4.58	4.53
ME (Kcal/kg)	2950	3108	3180	2950	3108	3180	2950	3108	3180	2950	3108	3180
Lysine	1.32	1.19	1.05	1.32	1.19	1.05	1.32	1.19	1.05	1.32	1.19	1.05
Methionine	0.50	0.48	0.43	0.53	0.50	0.47	0.58	0.54	0.51	0.60	0.57	0.54
Cystine	0.37	0.35	0.33	0.32	0.29	0.29	0.26	0.24	0.23	0.24	0.21	0.20
Calcium	1.00	0.84	0.80	1.00	0.84	0.80	1.00	0.84	0.80	1.00	1.02	0.80
Phosphorus	0.50	0.42	0.40	0.50	0.42	0.40	0.50	0.42	0.40	0.50	0.42	0.40
Tyrosine	0.84	0.78	0.75	0.71	0.64	0.61	0.55	0.48	0.46	0.48	0.41	0.38
Tryptophan	0.24	0.21	0.19	0.19	0.17	0.15	0.17	0.14	0.12	0.15	0.12	0.11

G1 (control group fed basal diet), G2 (group contains 6% BSF), G3 (group contains 12% BSF), G4 (group contains 15% BSF).

Table (2.1): Effect of BSF in the diet of Cobb 500 broilers on carcass characteristics and return of some carcass parts:

Parameters	G1 Mean ±SE	G2 Mean ±SE	G3 Mean ±SE	G4 Mean ±SE	P value
Dressing (%)	76.27 [a] ±0.78	73.00 [ab] ±1.2	71.74 [b] ±0.39	71.23 [b] ±0.57	0.003
Breast (%) without bone	25.03 [a] ±1.09	24.02 [a] ±1.38	19.52 [b] ±0.59	19.75 [b] ±0.82	0.003
Breast (%) with bone	30.09 [a] ±0.69	29.35 [ab] ±1.14	26.21 [ab] ±0.84	24.81 [b] ±1.56	0.016
Thigh (%)	29.76 [a] ±0.46	27.26 [b] ±0.64	29.21 [ab] ±0.49	29.24 [ab] ±0.49	0.027
Liver (%)	2.16 ±0.16	2.61 ±0.16	2.37 ±0.06	2.68 ±0.17	0.097
Heart (%)	0.53 ±0.04	0.41 ±0.08	0.59 ±0.06	0.6 ±0.03	0.147
Spleen (%)	0.16 ±0.02	0.20 ±0.02	0.16 ±0.03	0.16 ±0.01	0.573
Thymus (%)	0.37 ±0.04	0.45 ±0.07	0.34 ±0.05	0.45 ±0.05	0.398
Bursa (%)	0.13 [a] ±0.01	0.16 [a] ±0.02	0.07 [b] ±0.01	0.07 [b] ±0	0.000
Lung (%)	0.39 [b] ±0.04	0.46 [ab] ±0.03	0.5 [a] ±0.01	0.44 [ab] ±0.01	0.044
Gizzard	1.82 ±0.13	1.94 ±0.11	2.09 ±0.11	2.12 ±0.08	0.243
Abdominal fat (%)	0.98 ±0.04	1.01 ±0.16	1.27 ±0.04	1.1 ±0.17	0.355
Intestine%	4.00 [b] ±0.14	4.22 [ab] ±0.39	4.91 [ab] ±0.17	5.17 [a] ±0.21	0.017
Return from thigh	29.6 ±1.83	26.86 ±1.68	26.84 ±1.38	26.18 ±0.95	0.414
Return from gizzard and liver	4.41 ±0.17	4.89 ±0.31	4.46 ±0.25	4.61 ±0.31	0.590
Return from other parts	8.03 ±0.54	7.97 ±0.31	7.92 ±0.32	7.46 ±0.31	0.718

Means carrying a-b-c significantly different among different groups of the same row. G1 (control group fed basal diet), G2 (group contains 6% BSF), G3 (group contains 12% BSF), G4 (group contains 15% BSF).

Table (2.2): Effect of BSF in the diet of Cobb 500 broilers on carcass characteristics and return of some carcass parts:

Parameters	G1 Median (Q1-Q3)	G2 Median (Q1-Q3)	G3 Median (Q1-Q3)	G4 Median (Q1-Q3)	P value
Live weight (g)	2430.00 (2198.75 - 2845)	2415 (2137.5 – 2865)	2280 (2130 – 2475)	2257.5 (2117.5 - 2337.5)	0.599
Gizzard fat weight (%)	0.468[b] (0.3375- 0.497)	0.453[b] (0.3838- 0.5262)	0.66 [a] (0.5611-1.1275)	0.67 [a] (0.4937-0.8465)	0.028
Return from breast	48.4 [a] (40.7-61.8)	44.3 [ab] (38.21-61.71)	36.38[b] (32.43-38.64)	34.79[b] (32.83-38.28)	0.029
Return from carcass	89.41 (78.86-108.75)	82.98 (74.39-106.04)	75.28 (68.78-81.08)	72.74 (70.47-77.48)	0.093

Medians carrying a-b-c significantly different among different groups of the same row.

Table (3): Effect of BSF in the diet of Cobb 500 broilers on meat quality of breast meat:

Items	G1 Mean ±SE	G2 Mean ±SE	G3 Mean ±SE	G4 Mean ±SE	P value
Tenderness	66.68[a]±0.89	57.27[b]±2.18	49.06[c]±0.6	63.35[a]±0.95	0.000
PH	5.41±0.05	5.66±0.11	5.73±0.25	5.36±0.17	0.35
L*(lightness)	53.21±1.38	55.54±1.91	55.15±2.59	53.15±1.92	0.759
a* (redness)	2.27±0.04	2.60±0.11	2.61±0.03	2.44±0.1	0.047
b* (yellowness)	9.35±0.36	9.14±0.38	8.37±0.23	8.72±0.09	0.152
Chroma	9.62±0.35	9.51±0.4	8.76±0.21	9.05±0.1	0.206
Hue angel	76.32[a]±0.53	74.13[ab]±0.08	72.65[b]±0.6	74.41[ab] ±0.56	0.005
Drip loss 24 hr	4.09 ±0.41	4.41 ±0.56	3.42 ±0.55	6.18 ±1.7	0.283
Drip loss 48hr	4.67 ±0.48	5.03 ±0.53	4.2 ±0.67	7.35 ±1.74	0.199
Cooking loss	23.23 ±0.7	23.1 ±2	24.04 ±1.51	24.52 ±1.5	0.892
WHC%	83.02 ±0.18	80.87 ±1.48	81.85 ±1.07	83.99 ±0.77	0.214
Items	G1 Median (Q1-Q3)	G2 Median (Q1-Q3)	G3 Median (Q1-Q3)	G4 Median (Q1-Q3)	P value
MDA	51.36[a] (49.99 - 52.89)	23.61[ab] (20.88 - 9.42)	21.1[b] (19.98-22.82)	24.69[ab] (24.62-50.28)	0.041

Means or medians carrying a-b-c significantly different among different groups of the same row.
G1 (control group fed basal diet), G2 (group contains 6% BSF), G3 (group contains 12% BSF), G4 (group contains 15% BSF)

3. RESULT

3.1. Carcass characteristics

Table 2 shows that there were no changes in live weight (LW), relative weights of liver, heart, spleen, thymus, gizzard, or abdominal fat between groups. Additionally, G2 (fed BSF6%) recorded non-significant differences in dressing percentage and relative weights of the bursa of Fabricius, intestine, gizzard fat, and breast weight with and without bone compared to G1, while G2 and G3 decreased in dressing percentage, breast with bone, and bursa of Fabricius. Groups fed BSF at levels 12 and 15% showed a non-significant difference in thigh weight compared to the

control group (% 29.76, 27.26, 29.21, and 29.24 for G1, G2, G3, and G4, respectively), while G2 decreased compared to G1. In terms of return from breast, G2 showed no change, while G3 and G4 showed a decrease compared to G1, while return from carcass showed no difference across all treated groups.

3.2. Meat quality

Meat quality parameters, as presented in Table 3, showed that feeding BSF at different levels resulted in a non-significant effect on drip loss at 24 and 48 hrs, cooking loss, WHC, PH, meat colour (a*, b*, L*), and chroma. In comparison to the control group, G2 and G3 recorded a significant decrease in tenderness, but G4 was non-significant with G1 (66.68, 57.27, 49.06, and 63.35 for G1, G2, G3, and G4, respectively). On the other hand, group fed BSF at 12% showed a significant lower in MDA confront to G1 (51.36 and 21.1 for G1 and G3, respectively).

3.3. Cecal microbiota

As elucidated in Figure 1, BSF didn't affect normal inhabitant bacteria of the intestine, such as Lactobacillus, or the total bacterial count (TBC), nor did it increase pathogenic bacteria, such as Salmonella. Additionally, G3 recorded a numerical increase in lactobacillus compared to the control group (11.99, 9.98, 12.08, and 9.99for G1, G2, G3, and G4, respectively), while salmonella was negative in all treated groups.

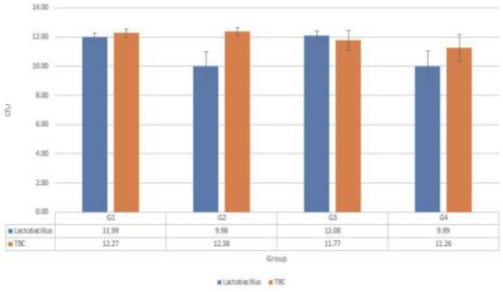

Fig.1 effect of BSF in the diet of Cobb 500 broiler chicke3ns on cecal microbiota

4. DISCUSSION

Carcass traits are essential factors in determining commercial portion yields (Pieterse *et al.,* 2019). Concerning the effect of the inclusion of BSF on carcass traits, groups fed different levels of BSF showed no significant effect on carcass traits. Additionally, no differences in the weight of internal organs (relative weight of liver, heart, spleen, thymus, and gizzard) were found; however, dressing% and the weights of the bursa of Fabricius and breast weight without bone showed significantly decreased in G3 and G4 compared to G1.Also, Pieterse *et al*. (2019) showed that the inclusion of BSF pre-pupae meal at different dietary levels (up to 15%) had no change on the carcass characteristics (the live slaughter weight, cold carcass weight or dressing percentage of the broilers as well as the commercial cut yields).Similarly, Cullere *et al*. (2016) who found that Broiler quails that fed diet containing BSF larvae meal (10%,15%) didn't show any differences in carcass weight, breast weight breast meat yield, and dressing % in compared to control broiler chicken fed modified BSF larvae fat showed non-significant difference in the carcass traits (slaughter weight, carcass weight , slaughter yield%, breast%, thigh%, spleen % , liver % , bursa of Fabricius %, heart %,gizzard %,intestine%) (Dabbou *et al.,* 2021) .Also, Auza *et al.* (2021) conclude that the BSF larvae meal didn't impact the relative weight of internal organs or the chickens' digestive systems, and had no impact on the spleen weight %. Also, Schiavone *et al.* (2017) mentioned that substitution of soybean oil by 50% or 100% BSLF in broiler chickens diet showed non-significant difference in carcass characteristics (live weight (LW), carcass weight, breast without bone%, thighs, % intestinal fat, % liver g, heart g, spleen g). On the other hand, Raju *et al.* (2023) showed significant increased with high level of BSF larvae meal (>7.5% in diet) in dressing yield, breast weight, and abdominal fat content. Additionally, birds fed HI meal showed significant differences in live weight and carcass weight; however, there was no change in breast fillet yield (Altmann *et al.,* 2018). Also, Schiavone *et al.* (2019) reported that the carcass weight was significantly reduced with the inclusion levels (5, 10, and 15%) of BSF and severely decreased by high inclusion level (15%) of BSF. The reduction in live and carcass weights of broilers may be attributed to the chitin found in the exoskeleton of HI larvae (Longvah *et al.,* 2011). Broiler's diets supplemented with BSF larvae oil calcium salt at 2 and 3% showed decrease in slaughter weight, carcass weight, breast weight, thigh weight and abdominal fat (Aprianto *et al.,* 2023). The carcass weight and percentage of the carcass in the 50% HILM group were decreased compared to the control and 25% HILM groups (Kim *et al.,* 2021). As a result, inclusion of low level of BSF in the broiler dietmay maintain the carcass traits.

Feeding BSF at different levels resulted in a non-significant effect on meat colour (a*, b*, L*), PH, drip loss at 24 and 48 hrs, cooking loss, WHC, and chroma. Generally, changes in the pH of meat are connected with WHC, and variations in the pH of the meat in the breast are related to the carcass weight. Changes in pH occurred as a result of variations in the amount of muscle glycogen (Kim *et al.,* 2021). Our results were in agreement with Pieterse *et al*. (2019) who found that the inclusion of BSF pre-pupae meal at varied dietary levels (up to 15%) had no significant variations for colour parameters regarding the L*, a*, b*, hue, and chroma values of the broiler breast muscles. Also, cooking loss and thaw loss did not differ significantly by treatment. Dietary HILM supplementation at 25% and 50% resulted in no significant differences in lightness, yellowness, cooking loss, or shear force, but there were significant differences in pH, redness, and WHC that increased with adding HILM (25%, 50% HILM) compared to the control group (Kim *et al.,* 2021). According to Schiavone et al. (2017) the birds that fed diets with partial or total replacement of the soya with BSF larvae fat didn't show any changes in the pH of the meat. Also, Schiavone *et al.* (2017) and Schiavone *et al.* (2019) didn't notice a difference in the drip loss due to BSF fat or meal. The WHC and cooking loss are indices of the functional qualities of meat products and their suitability for processing, which enhance the meat's softness and juiciness (Aprianto *et al.,* 2023). Meat's WHC and cooking loss value

are closely related, and a high WHC is followed by a low cooking loss (Hutabarat *et al.*, 2021). Supplementing of HILM had no impact on the pH despite the carcass weight loss (Schiavone, *et al.*, 2019). Conversely, broiler quail breast meat's redness, pH and cooking loss were significant decreased, but its yellowness was unaffected (Cullere *et al.*, 2016). Additionally, the colour of the meat and egg yolks may have been impacted by a pigment produced from HILM and HI larval oil (Dalle Zotte *et al.*, 2019) and (Schiavone *et al.*, 2019). Also, the dietary BSF meal had a substantial impact on the colour parameters (Popova *et al.*, 2020). Broiler's diets supplemented with BSF larvae oil calcium salt at 2 and 3% showed significant increase in WHC and colour (a*, b*) while 3% significant decrease in a cooking loss (Aprianto *et al.*, 2023). Finally, Normal broiler breast flesh was reported to have a pH of 5.96 by (Van Laack *et al.*, 2000), which is comparable to the results of this trial. MDA is effective indicator of oxidative stress (Gui *et al.*, 2012). So, BSF displays anti-oxidant effects where significant decrease in MDA with increased level of BSF in the diet.

The dietary components of poultry have a major impact on the gut microbiota which is essential for digestion and uptake, growth and overall health condition (Torok *et al.*, 2011) and (Oakley *et al.*, 2014). Global interest is growing in the application of insect-based diets as a potential feed additive to enhance gut health and gastrointestinal function in poultry (Ndotono *et al.*, 2022). BSF larvae contain an antimicrobial peptide (AMP) that inhibits the growth of a variety of harmful bacteria, as well as monolaurin compounds derived from lauric acid that have antibacterial properties, which damage bacteria's lipid membrane (Park *et al.*, 2014) and (Abd El-hack *et al.*, 2020). In our study, Inclusion of BSF didn't affect on normal inhabitant bacteria of intestine as lactobacillus and TBC and not increase pathogenic bacteria as salmonella. Similarly, there were non-significant differences in lactobacillus and TBC between different treated groups. According to Lee *et al.* (2018), the BSF larva may have a positive impact on the immunity and ability to survive a salmonella infection. Abd El-Hack *et al.* (2020) and Ndotono *et al.* (2022) recorded an increase in the lactic acid bacteria (LAB) in the diets that included BSF larvae, particularly with 75% This rise due to the presence of chitin in the BSF larvae diet. Borrelli *et al.* (2017) found that Chitin is naturally a polysaccharide which can be fermented by microbes broke down by short chain fatty acid producing bacteria, it can also serve as a meal for microbes. There was favorable impact on the cecal microbiota with low inclusion levels 5% of HI meals However, high inclusion levels above 15% may reduce microbial complexity (Biasato *et al.*, 2020). Velten *et al.* (2018) observed that broiler chickens fed diets with 11.9% BSF instead of soybean meal had higher populations of Lactic acid bacteria, Coliform bacteria, and Clostridia.

5. CONCLUSIONS

In this trial, inclusion of BSF at various levels had no change on carcass traits or cecal microbiota. Regarding the meat quality measures, BSF supplementation had no adverse impact on the chicken breast meat; the L*, a*, b*, hue, and chroma values were not influenced with treatment, giving a similar colour to muscles from chicks supplied with the control diet, which is similar to chicken meat that is offered in stores. Additionally, BSF displays anti-oxidant effects, with a significant decrease in MDA with an increase in BSF levels in the diet. The pH, WHC and cooking loss, or shear force, did not affect Thus, the overall data suggest that BSF-fed broilers chicken breast meat may help increase consumer satisfaction with the meat.

6. REFERENCES

1. Abd el-hack, M. E., Shafi, M. E., Alghamdi, W. Y., Abdelnour, S. A., Shehata, A. M., Noreldin, A. E., Ashour, E. A., Swelum, A. A., Al-sagan, A. A. and Alkhateeb, M. 2020. Black soldier fly (Hermetia illucens) meal as a promising feed ingredient for poultry: A comprehensive review. Agriculture, 10, 339.-1-31
2. Abro, Z., Kassie, M., Tanga, C., Beesigamukama, D. and Diiro, G. 2020. Socio-economic and environmental implications of replacing conventional poultry feed with insect-based feed in Kenya. Journal of Cleaner Production, 265, 121871.
3. Adeniji, A. 2007. Effect of replacing groundnut cake with maggot meal in the diet of broilers. International journal of poultry science, 6, 822-825.
4. Altmann, B. A., Neumann, C., Velten, S., Liebert, F. and Mörlein, D. 2018. Meat quality derived from high inclusion of a micro-alga or insect meal as an alternative protein source in poultry diets: A pilot study. Foods, 7, 34.1-15 https://doi.org/10.3390/foods7030034
5. Aprianto, M. A., Kurniawati, A., Hanim, C., Ariyadi, B. and Al anas, M. J. P. S. 2023. Effect supplementation of black soldier fly larvae oil (Hermetia illucens L.) calcium salt on performance, blood biochemical profile, carcass characteristic, meat quality, and gene expression in fat metabolism broilers. Poultry Science, 102, 102984.
6. Ashraf, R. and Shah NP. 2011. Selective and differential enumerations of Lactobacillus delbrueckii subsp. bulgaricus, Streptococcus thermophilus, Lactobacillus acidophilus, Lactobacillus casei and Bifidobacterium spp. in yoghurt—A review. International journal of food microbiology, 149, 194-208.
7. Auza, F., Purwanti, S., Syamsu, J. and Natsir, A. The relative weight of internal organs and digestive tract in native chickens age 12 weeks that are given various levels of BSF larvae meal (Hermetia illucens L) in the ration. IOP Conference Series: Earth and Environmental Science, 2021. IOP Publishing, 012064.
8. Barragan-Fonseca, K. B., Dicke, M., Van loon and Ja, J. 2017. Nutritional value of the black soldier fly (Hermetia illucens L.) and its suitability as animal feed–a review. Journal of Insects as Food and Feed, 3, 105-120.
9. Biasato, I., Ferrocino, I., Dabbou, S., Evangelista, R., Gai, F., Gasco, L., Cocolin, L., Capucchio, M. T. and Schiavone, A. 2020. Black soldier fly and gut health in broiler chickens: insights into the relationship between cecal microbiota and intestinal mucin composition. Journal of Animal Science and Biotechnology, 11, 1-12.
10. Biesek, J., Kuźniacka, J., Banaszak, M. and Adamski, M. 2020. The quality of carcass and meat from geese fed diets with or without soybean meal. Animals, 10, 200.1-11
11. Borrelli, L., Coretti, L., Dipineto, L., Bovera, F., Menna, F., Chiariotti, L., Nizza, A., Lembo, F. and Fioretti, A. 2017. Insect-based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens. Scientific reports, 7, 16269.
12. Commission Ti, C. C., Com- T, Committee Ciec 1977. Commission TI, Committee CIEC, Com- T, Committee CIEC (1977) CIE recommendations on uniform color spaces, color-

difference equations, and metric color terms. Color Res Appl 2(1):5–6.
13. Cullere, M., Tasoniero, G., Giaccone, V., Miotti-scapin, R., Claeys, E., De smet, S. and Dalle zotte, A. 2016. Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits. Animal, 10, 1923-1930.
14. Dabbou, S., Lauwaerts, A., Ferrocino, I., Biasato, I., Sirri, F., Zampiga, M., Bergagna, S., Pagliasso, G., Gariglio, M. and Colombino, E. 2021. Modified black soldier fly larva fat in broiler diet: Effects on performance, carcass traits, blood parameters, histomorphological features and gut microbiota. Animals, 11, 1837.1-20. https://doi.org/10.3390/ani11061837.
15. Dalle zotte, A., Singh, Y., Michiels, J. and Cullere, M. 2019. Black soldier fly (Hermetia illucens) as dietary source for laying quails: live performance, and egg physico-chemical quality, sensory profile and storage stability. Animals, 9, 115.
16. FAO 2013. Food and Agriculture Organization of the United Nations (FAO) 2013. Edible insects – future prospects for food and feed security. FAO Forestry Paper No. 171, FAO, Rome, Italy, p. ix.
17. Gui, D., Guo, Y., Wang, F., Liu, W., Chen, J., Chen, Y., Huang, J. and Wang, N. 2012. Astragaloside IV, a novel antioxidant, prevents glucose-induced podocyte apoptosis in vitro and in vivo. PloS one, 7(6), e39824.
18. Hutabarat, R., Suardana, I. W. and Swacita, I. B. N. 2021. The Comparison of The Quality of Balinese and Landrace Porks in Terms of Water Holding Capacity and Cooking Loss. Journal of Veterinary and Animal Sciences, 4.(1): 26-31.
19. Karatas, F., Karatepe, M. and Baysar, A. 2002. Determination of free malondialdehyde in human serum by high-performance liquid chromatography. Analytical biochemistry, 311, 76-79.
20. Kareem, K. Y., Abdulla, N. R., Foo, H. L., Zamri, A. N. M., Shazali, N., Loh, T. C. and Alshelmani, M. I. 2018. Effect of feeding larvae meal in the diets on growth performance, nutrient digestibility and meat quality in broiler chicken. Indian Journal of Animal Sciences, 88, 1180-1185.
21. Khan, S., Naz, S., Sultan, A., Alhidary, I., Abdelrahman, M., Khan, R., Khan, N., Khan, M. and Ahmad, S. 2016. Worm meal: a potential source of alternative protein in poultry feed. World's Poultry Science Journal, 72, 93-102.
22. Kim, B., Bang, H. T., Kim, K. H., Kim, M. J., Jeong, J. Y., Chun, J. L. & Ji, S. Y. 2020. Evaluation of black soldier fly larvae oil as a dietary fat source in broiler chicken diets. Journal of Animal Science and Technology, 62, 187-197.
23. Kim, B., Kim, H. R., Lee, S., Baek, Y.-C., Jeong, J. Y., Bang, H. T., Ji, S. Y. and Park, S. H. 2021. Effects of dietary inclusion level of microwave-dried and press-defatted black soldier fly (Hermetia illucens) larvae meal on carcass traits and meat quality in broilers. Animals, 11, 665.1-11-https://doi.org/10.3390/ani11030665
24. Lee, J., Kim, Y.-M., Park, Y.-K., Yang, Y.-C., Jung, B.-G. and Lee, B.-J. 2018. Black soldier fly (Hermetia illucens) larvae enhances immune activities and increases survivability of broiler chicks against experimental infection of Salmonella Gallinarum. Journal of Veterinary Medical Science, 80, 736-740.
25. Longvah, T., Mangthya, K. and Ramulu, P. 2011a. Nutrient composition and protein quality evaluation of eri silkworm (Samia ricinii) prepupae and pupae. Food chemistry, 128, 400-403.
26. Makkar, H. P., Tran, G., Heuzé, V. and Ankers, P. 2014. State-of-the-art on use of insects as animal feed. Animal feed science and technology, 197, 1-33.
27. Marono, S., Loponte, R., Lombardi, P., Vassalotti, G., Pero, M., Russo, F., Gasco, L., Parisi, G., Piccolo, G. and Nizza, S. 2017. Productive performance and blood profiles of laying hens fed Hermetia illucens larvae meal as total replacement of soybean meal from 24 to 45 weeks of age. Poultry Science, 96, 1783-1790.
28. Maturin, L. and Peeler, J. 2001. Bacteriological Analytical Manual (BAM) Chapter 3: Aerobic plate count. US Food and Drug Administration: Silver Spring, MD, USA.
29. Ndotono, E. W., Khamis, F. M., Bargul, J. L. and Tanga, C. M. 2022. Insights into the Gut Microbial Communities of Broiler Chicken Fed Black Soldier Fly Larvae-Desmodium-Based Meal as a Dietary Protein Source. Microorganisms, 10, 1351.1-14.
30. Oakley, B. B., Lillehoj, H. S., Kogut, M. H., Kim, W. K., Maurer, J. J., Pedroso, A., Lee, M. D., Collett, S. R., Johnson, T. J. and Cox, N. A. 2014. The chicken gastrointestinal microbiome. FEMS microbiology letters, 360, 100-112.
31. Onsongo, V., Osuga, I., Gachuiri, C., Wachira, A., Miano, D., Tanga, C., Ekesi, S., Nakimbugwe, D. and Fiaboe, K. 2018. Insects for income generation through animal feed: effect of dietary replacement of soybean and fish meal with black soldier fly meal on broiler growth and economic performance. Journal of economic entomology, 111, 1966-1973.
32. Park, S. I., Chang, B. S. and Yoe, S. M. 2014. Detection of antimicrobial substances from larvae of the black soldier fly, H ermetia illucens (D iptera: S tratiomyidae). Entomological Research, 44, 58-64.
33. Pieterse, E., Erasmus, S. W., Uushona, T. and Hoffman, L. C. 2019. Black soldier fly (Hermetia illucens) pre-pupae meal as a dietary protein source for broiler production ensures a tasty chicken with standard meat quality for every pot. Journal of the Science of Food and Agriculture, 99, 893-903.
34. Popova, T. L., Petkov, E. and Ignatova, M. 2020. Effect of black soldier fly (Hermetia illucens) meals on the meat quality in broilers. Agricultural and Food Science, 29, 177–188-177–188.
35. Raju, M., Rao, S. R., Paul, S., Prakash, B., Reddy, M., Kannan, A., Shanmugam, M. and Kumar, P. S. P. 2023. Source variation in nutrient profile and the effects of Black soldier fly (Hermetia illucens) larva meal at graded levels in diet on performance, carcass traits, serum biochemical profile and cellular immune response in broiler chicken. International Journal of Tropical Insect Science, preprint.
36. Sánchez-Muros, M.-J., Barroso, F. G. and Manzano-Agugliaro, F. 2014. Insect meal as renewable source of food for animal feeding: a review. Journal of Cleaner Production, 65, 16-27.
37. Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., Bergagna, S., Dezzutto, D., Gai, F., Dabbou, S. and Gasco, L. 2017. Partial or total replacement of soybean oil by black soldier fly larvae (Hermetia illucens L.) fat in broiler diets: Effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. Italian Journal of Animal Science, 16, 93-100.
38. Schiavone, A., Dabbou, S., Petracci, M., Zampiga, M., Sirri, F., Biasato, I., Gai, F. and Gasco, L. 2019. Black soldier fly defatted meal as a dietary protein source for broiler chickens: Effects on carcass traits, breast meat quality and safety. Animal, 13, 2397-2405.
39. SPSS 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.
40. Sugiharto, S. 2016. Role of nutraceuticals in gut health and growth performance of poultry. 15, 99-111.
41. Torok, V. A., Hughes, R. J., Mikkelsen, L. L., Perez-Maldonado, R., Balding, K., Macalpine, R., Percy, N. J. and Ophel-Keller, K. 2011. Identification and characterization of potential performance-related gut microbiotas in broiler chickens across various feeding trials. Applied and environmental microbiology, 77, 5868-5878.
42. Van Huis, A. 2013. Potential of insects as food and feed in assuring food security. Annual review of entomology, 58, 563-583.
43. Van Laack, R., Liu, C.-H., Smith, M. and Loveday, H. 2000. Characteristics of pale, soft, exudative broiler breast meat. Poultry Science, 79, 1057-1061.

44. Velten, S., Neumann, C., Bleyer, M., Gruber-Dujardin, E., Hanuszewska, M., Przybylska-Gornowicz, B. and Liebert, F. 2018. Effects of 50 percent substitution of soybean meal by alternative proteins from Hermetia illucens or Spirulina platensis in meat-type chicken diets with graded amino acid supply. Open Journal of Animal Sciences, 2018, 8, 119-136.
45. Wu, P., Golly, M. K., Guo, Y., Ma, H., He, R., Luo, X., Luo, S., Zhang, C., Zhang, L. and Zhu, J. 2020. Effect of partial replacement of soybean meal with high-temperature fermented soybean meal in antibiotic-growth-promoter-free diets on growth performance, organ weights, serum indexes, intestinal flora and histomorphology of broiler chickens. Animal Feed Science and Technology, 269, 114616.