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EFFECT OF REPLACEMENT OF SOYBEAN MEAL BY SILKWORM MEAL ON GROWTH PERFORMANCE, APPARENT METABOLIZABLE ENERGY AND NUTRIENT DIGESTIBILITY IN BROILERS AT DAY 28 POST HATCH

R. Ullah[1], S. Khan[1], N. A. Khan[2*], M. Tahir[2] and N. Ahmad[1]

[1]Department of Poultry Science, The University of Agriculture Peshawar, Pakistan; [2]Department of Animal Nutrition, The University of Agriculture Peshawar, Pakistan
[*]Corresponding Author Email: nazir.khan@aup.edu.pk

ABSTRACT

This study evaluated the effect of replacing soybean meal with silkworm meal on production performance, apparent metabolizable energy (AME) and apparent nutrients digestibility in broiler during starter phase. Five *iso-nitrogenous* and iso-caloric diets were formulated by stepwise i.e. 0% (SM0), 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) replacement of soybean meal with silkworm meal in broiler ration. Two hundred and fifty broiler day-old chicks were divided into twenty-five replicate groups (n=10), with five replicates per diet using a completely randomized design. The silkworm meal analysis showed higher levels of crude protein (57.6 ± 1.50%) and crude fat (23.3 ± 0.21%). The silkworm meal has higher contents (g/100g of total amino acids) of lysine (7.52 ± 0.376) and methionine (3.88 ± 0.376), but was slightly deficient in tryptophan (1.70 ± 0.413). Mean intake of feed, gain in body weight and dressing percentage were higher ($P < 0.05$) in group SM75 in comparison with other groups. Moreover, better ($P < 0.05$) FCR was observed for SM0 (1.58± 0.031) and SM75 (1.59 ± 0.071) groups than SM50 (1.62 ± 0.030) group. The AME was higher ($P < 0.05$) in group SM75 and SM100 in comparison with other groups. The digestibility of dry matter, crude protein, crude fat, ash and N free extract did not differ ($P > 0.05$). The organoleptic quality parameters were not altered ($P > 0.05$) due to replacement of soybean meal by silkworm meal. The findings of the present study revealed that silkworm meal may effectively be used by replacing 75% soybean meal as low-cost protein ingredient in broiler ration.

Keywords: Protein source; Insect protein; Amino acid profile, Feed conversion ratio.

INTRODUCTION

Poultry production is heavily depended on plant-seeds based protein ingredients, particularly soybean meal due to its high nutrients availability and excellent amino acid profile (Willis, 2003). In many countries such as Pakistan the production of soybean is limited and as such most of the soybean used in poultry ration is imported from other countries. The cost of soybean has significantly increased over the past few decades due the rapid growth of poultry industry on global basis, as well as by the rising demand of soybean in human food industry (Hansen and Gale 2014; Ullah *et al*., 2017).The increasing cost of protein ingredients has provided impetus to the poultry industry to explore unconventional low-cost, sustainable sources of protein ingredients in poultry ration (Ramos-Elorduy *et al*., 2002; Das *et al*., 2009). Recently there is a growing interest in the use some of the protein-rich insect species as a low-cost protein ingredient in poultry ration (Van-Hhuis *et al*., 2013). Insects reproduce and grow very fast, had high efficiency of feed conversion and can be fed on bio-wastes materials. Some insect species can potentially convert 2 kg of domestic organic wastes biomass into 1 kg of insect biomass (Collavo *et al*., 2005), which can be used as a valuable food and feed resource (Ullah *et al*., 2017). Recent studies have demonstrated that commercial production of insects is technically feasible, and insects can be used as low-cost, sustainable, alternative protein ingredient in poultry ration (Veldkamp *et al*., 2012), and the benefits could be particularly greater, if insects are fed on bio-waste substrates.

Silkworm which can be produced as co-product of the silk industry, is a caterpillar of moth butterfly (*Bombyx Mori*) whose cocoon is used for silk production. Due to its high protein content and digestibility silkworm meal can be used protein ingredient in livestock feed, notably for poultry and other monogastric species (Trivedy *et al*., 2008). Silkworm caterpillar meal is rich in protein (56.8-63.8%), lipid (19.6-31.5%) and ash (3.3-7.7%) (Loselevich *et al.,* 2004; Makkar *et al*., 2014). Apart from these nutrients, it has an amino acid profile which in most cases compares favorably with those of fish meal (Solomon and Yusufu, 2005). However, according to our knowledge, proper review work has been done on the nutritional value of silkworm caterpillar meal produced in Pakistan as animal feed. Therefore, the present study was designed to quantify proximate chemical composition, metabolizable energy content, and amino acids and mineral profile of the indigenous silkworm caterpillar meal, soybean as well as to assess its potential as protein ingredient in broiler feed.

MATERIALS AND METHODS

Preparation of Silkworm Meal: Sun dried silkworm pupae with their chitinous covering was obtained from the Changa Manga Silk Industries (31°05′N latitude 73°58′E longitude) District Kasur, Pakistan. For silk production, the silkworms are killed in the pupa stage before they produce proteolytic enzymes for disruption of silk cocoon. The cocoons are soaked in hot water and multiple threads are joined, a spinning machine unravels it from the cocoons to produce silk and large quantities of spent pupa are produced as by-product. For the current study, the spent silkworm pupae were obtained from two consecutive batches at two weeks interval. The spent pupas were dried in sun, crushed manually with proximately analyzed and chitinous matter were removed. The pupa matter was ground and used for the preparation of experimental diets.

Chemical analysis of diets (SBM, soybean meal; SWM, silkworm meal): The diet and silkworm meal samples were dried in oven at temperature of 60 ºC and milled particles (1 mm) for chemical analysis. The dried, ground samples were analysed for the contents of dry matter, crude protein, crude fat, and ash according to the standard procedure of AOAC (2005).The contents of Ca, Mg, Mn, Fe, Cu and Zn were analysed by atomic absorption spectrophotometer (Buck Scientific 240VGP, Milan, Italy) according to the procedures of AOAC (2005).The silkworm meal samples was run for amino acid determination via High Performance Liquid Chromatography (HPLC) followed the procedures of Cserhati and Forgacs (1999) and Kerese (1984).

Diets, Experimental Layout and Management of Birds: Two hundred and fifty broiler one-day-old chicks (Ross 308) were randomly divided into twenty five replicate groups. Each replicate group was kept in 10 ×10 feet cages, housed in the same poultry shed. Five replicates were randomly assigned to each of the five experimental diets according to a completely randomized design (CRD). The five diets were formulated at 0% (SM0), 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) replacement of soybean meal by silkworm meal in a commercial broiler feed. The experimental feeds were pelleted using experimental pellet machine (Parr Instrument Co, USA) at the University of Agriculture Peshawar. The ingredient and chemical composition of four diets formulated on iso-nitrogenous and iso-caloric basis is given in Table 1.

Separate feeder and drinker were provided in each cage for provision of water and feed *ad libitum*. Locally adopted vaccination schedule was practiced for vaccination against prevalent diseases. The trial continued for 28 days and data on intake of feed by each replicate group were recorded daily basis. Body weight of all experimental birds were recorded individually at start of the study and then on weekly basis. For each experimental unit, the FCR was computed weekly. For calculation of dressing percentage, three birds per replicate were randomly selected and processed for dressing percentage.

Measurement of Apparent Metabolizable Energy (AME): To measure the metabolizable energy (kcal/kg), 5 birds from each replicate group were transferred to specialized metabolic cages for digestibility analysis. Birds were individually fed with known quantity of feed. The faeces were collected and immediately weighed, every next morning, transferred to pre-labelled polythene zip bags and immediately frozen. Data were collected for 4 consecutive days and feaces samples were taken at the end of trial for analysis as mentioned by Sultan *et al.,* (2014). Feed and excreta gross energy were measured by (Bomb calorimeter- IKA Werke, C7000 & Co. Staufen Germany) and values were calculated by the following formula.

$$\text{AME (kcal/kg)} = \left[\frac{(\text{Energy content of feed} \times \text{feed intake}) \times (\text{Energy content of feaces} \times \text{feaces lost})}{(\text{Energy content of feed} \times \text{feed intake})}\right]$$

Nutrients digestibility: Digestibility of dry matter (DM), crude protein (CP), crude fiber (CF), ash, ether extract (EE) nitrogen free extract (NFE) was determined on day 28 of the experimental trial. The detail method is reported earlier (Khan *et al*., 2016a). Briefly, from each group replicate birds (n=5) were chosen and euthanized. Immediately after euthanization, birds were dissected and samples from ileum (diverticulum of ileo-cecal junction) and rectum were collected to find out the apparent total digestibility. For proximate composition, the collected samples were freeze-dried, ground with the help of 1-mm mesh screen, and analysed in duplicate. The chromic oxide (Cr_2O_3) 0.2% was used as indigestible maker to calculate the apparent total digestibility coefficients. The following formula was used

$$\text{Apparent digestibility} = 100 - \left|100 \times \frac{Nutreint(\%)indigesta \times Cr(\%)\,indiet}{Nutrient(\%)indiet \times Cr(\%)digesta}\right|$$

Where Cr = chromic oxide

Organoleptic study: Fresh meat samples from thigh, legs and breast were taken and immediately cooked each portion was wrapped in a new sheet of paper and held in an oven set at 93.3°C until subsequent slicing and serving. The cooked samples were independently evaluated by a panel of experts in accordance with procedure mentioned by Khan *et al*. (2016b). The samples were evaluated for taste, juiciness, color, flavor and tenderness on 5-point hedonic scale. Panelists were asked to evaluate slice attributes based on a 9-point scale. Attributes included: overall liking (1 = dislike extremely; 9 = like extremely), flavor liking (1 = dislike extremely; 9 = like extremely), juiciness liking (1 = dislike extremely; 9 = like extremely), and tenderness liking (1 = dislike extremely; 9 = like extremely).

Statistical analysis: The effect of replacing soybean meal with silkworm meal on the production performance parameters, AME and nutrients digestibility was analyzed according to GLM procedure of Statistical Analysis System (SAS, 2009). The model used as where, Y_{ij} is the dependent variable; μ, is the overall mean; D_i, is the fixed effect of experimental diets (i = 1-5) and $Є_{ij}$ is the random error. When significant (P < 0.05) differences were detected, post-hoc analyses were carried out using Tukey-Kramer test to compute pair-wise differences in the means. Replicate was used as experimental unit.

RESULTS

Data on the chemical profile, amino acids and mineral composition of silkworm meal are summarized in Table 2, 3 and 4, respectively. The higher content of CP (57.6% of DM) in silkworm meal indicates its potential scope as protein ingredient as well as a rich source of crude fat (23.3%) in poultry feed (Table 2). Moreover, essential amino acids were present in silkworm meal with higher contents (g/100 g total amino acids) of lysine (7.52) and methionine (3.88), but was slightly deficient in tryptophan (1.70) (Table 3). The silkworm meal is particularly rich in Zn (222 mg/kg) and Fe (326 mg/kg) (Table 4).

The highest (P < 0.05) feed intake and weight gain was recorded for SM75 group (Table 5). The better (P < 0.05) FCR was observed for SM0 (1.58 ± 0.031) and SM75 (1.59 ± 0.071) groups in comparison with SM50 (1.62 ± 0.030) group, whereas the FCR for diets SM25, and SM100 was not affected (P > 0.05). The SM0 group consumed lower amount of feed in comparison with other groups whereas SM25 and SM100 groups had lower feed intake than SM50 and SM75 groups (P<0.05). Weight gain for group SM0, SM25 and SM100 was lower than groups SM50 and SM75, whereas SM75 had higher weight gain and dressing percentage than all other groups (P<0.05). Dressing percentage of SM0 and SM100 groups was lower than SM0 group, however SM25 group had lower dressing percentage than SM50 group (P < 0.05) (Table 5).

The AME was higher in SM75 and SM100 groups in comparison with SM0, SM25 and SM50 groups. Higher AME was observed in SM50 group than SM0 group (P<0.05) whereas SM25 group was not affected (Table 6). Data on the effect of replacement of soybean meal by silkworm meal on apparent total digestibility of nutrients is summarized in Table 7. The digestibility of dry matter, crude protein, crude fat, ash and Nitrogen free extract did not differ due to diet composition (P>0.05). The samples was cooked in an oven set at 93.3°C, taste, tenderness, juiciness, color and flavor of broiler meat was not affected by the test diets (P>0.05) (Table 8).

Table 1. Ingredient and chemical composition of experimental rations for broiler at starter phase.

	Diets* (soybean: silkworm)				
	SM0 (100:0)	**SM25 (75:25)**	**SM50 (50:50)**	**SM75 (25:75)**	**SM100 (0:100)**
Ingredients‡					
Corn	54	54	54	54	54
Broken Rice	2.4	2.9	3.4	3.9	4.4
Cotton meal	5	5	5	5	5
Guar meal	4	4	4	4	4
Sunflower meal	3.4	3.4	3.4	3.4	3.4
Soybean meal	10	7.5	5	2.5	0
Silk worm meal	0	2	4	6	8
Maize gluton meal (30%)	7.4	7.4	7.4	7.4	7.4
Fishmeal 50%	5	5	5	5	5
Rice polish	6	6	6	6	6
Molasses	1	1	1	1	1
Lime stone	0.4	0.4	0.4	0.4	0.4
Rock phosphate	01	01	01	01	01

Lysine	0.1	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1	0.1
Vitamins Minerals premix#	0.1	0.1	0.1	0.1	0.1
Calculated chemical composition†					
Dry matter (%)	87.2	87.8	87.6	88.2	88.2
Metabolizable energy (kcal/kg)	2997	2989	2991	2986	2995
Crude protein	21.3	21.1	21.2	21.1	21.2
Ether extract	4.20	4.18	4.19	4.17	4.19
Fiber	3.95	3.91	3.93	3.91	3.94
Ash	5.48	5.42	5.44	5.45	5.47
Calcium	0.77	0.76	0.77	0.79	0.78
Phosphorous	0.31	0.29	0.30	0.31	0.31
Lysine (% of total amino acids)	1.36	1.36	1.37	1.38	1.39
Methionine (% of total amino acids)	0.46	0.52	0.58	0.64	0.70
Cysteine (% of total amino acids)	0.34	0.34	0.33	0.33	0.33

*SM0 is control diet, whereas in the other diets 25% (SM25), 50% (SM50), 75% (SM75) or 100% (SM100) of the soybean meal was replaced with silkworm meal.

‡, g/100 g dry matter, unless otherwise stated

Provides per kg of diet: Mn 80 mg; Zn 60 mg; Fe 60 mg; Cu 5 mg; Co 0.2 mg; I 1 mg; Se 0.15 mg; choline chloride 200 mg; vitamin A 12000 IU; vitamin SM50 2400 IU; vitamin E 50 mg; vitamin K3 4 mg; vitamin B1 3 mg; vitamin B2 6 mg; niacin 25 mg; calcium-d-pantothenate 10 mg; vitamin B6 5 mg; vitamin B12 0.03 mg; d-biotin 0.05 mg; folic acid 1 mg.

† g/100 g DM unless otherwise stated.

Table 2. Chemical composition of silkworm meal

Nutrients	Mean ± SE
Dry matter (DM; g/100 g feed)	92.1 ± 2.23
Crude protein (g/100 g DM)	57.6 ± 1.50
Crude fiber (g/100 g DM)	5.55 ± 0.018
Ash (g/100 g DM)	11.2 ± 1.01
Crude fat (g/100 g DM)	23.3 ± 0.21
Energy (Kcal/100 g DM)	453 ± 8.10

Table 3. Amino acid profile (g/100 g total amino acids) of silkworm meal

Amino acids	Mean ± SE
Alanine	5.22 ± 0.255
Arginine	6.31 ± 0.388
Aspartic acid	9.59 ± 0.740
Cystine	0.97 ± 0.388
Glutamic acid	10.19 ± 1.007
Glycine	4.61 ± 0.376
Histidine	3.28 ± 0.425
Isoleucine	4.73 ± 0.243
Leucine	7.04 ± 0.303
Lysine	7.52 ± 0.376
Methionine	3.88 ± 0.376
Proline	6.31± 0.510
Phenylalanine	5.58 ± 0.376
Serine	5.22 ± 0.243
Threonine	5.58 ± 0.121
Tyrosine	6.55 ± 0.303
Tryptophan	1.70 ± 0.413
Valine	5.70 ± 0.316

Table 4. Minerals profile of silkworm meal

Minerals	Mean ± SE
Calcium (g/kg dry matter (DM))	3.8± 2.11
Phosphorus (g/kg DM)	6.2 ± 2.30
Magnesium (g/kg DM)	3.3 ± 2.82
Iron (mg/kg DM)	326 ± 66.1
Manganese (mg/kg DM)	18.2 ±12.12
Copper (mg/kg DM)	15.0 ± 5.01
Zinc (mg/kg DM)	222 ± 72.2

Table 5. Effect of replacing soybean meal with silkworm meal on feed intake (g), weight gain (g), feed conversion ratio (FCR) and dressing percentage of broilers.

Diets[#] (SBM:SWM)[†]	Feed Intake (Mean ± SE)	Weight Gain (Mean ± SE)	FCR (Mean ± SE)	Dressing Percentage (Mean ± SE)
SM0 (100:0)	2758^{c}± 7.94	1743^{c}± 1.85	1.58^{b}± 0.031	63.3^{d} ± 0.31
SM25 (75:25)	2817^{b} ± 11.62	1747^{c}± 2.40	1.61^{ab}± 0.082	64.2^{c} ± 0.21
SM50 (50:50)	2935^{a}± 5.39	1814^{b}± 6.42	1.62^{a}± 0.030	66.3^{b} ± 0.25
SM75 (25:75)	2918^{a}± 8.33	1834^{a}± 1.33	1.59^{b}± 0.071	67.3^{a} ± 0.17
SM100(0:100)	2798^{b}± 8.89	1744^{c}± 4.70	1.61^{ab}± 0.033	63.3^{d} ± 0.13
P-Value	***	***	***	***

a-d, means with different letters within the column differs at P < 0.05; ***, P < 0.001
#SM0is control diet, whereas in the other diets 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) of the soybean meal was replaced with silkworm meal.
† SBM, soybean meal; SWM, silkworm meal.

Table 6. Effect of replacing soybean meal with silkworm meal on apparent metabolizable energy (AME) of broiler chicks.

Diets[#] (SBM:SWM)[†]	AME
SM0 (100:0)	12.7^{c}
SM25 (75:25)	12.8^{bc}
SM50 (50:50)	12.9^{b}
SM75 (25:75)	13.2^{a}
SM100 (0:100)	13.3^{a}
SEM	0.080
P-Value	***

abc, means with different letters within column differs at P < 0.05; ***, P < 0.001
#SM0is control diet, whereas in the other diets 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) of the soybean meal was replaced with silkworm meal.
†SBM, soybean meal; SWM, silkworm meal.

Table 7. Apparent nutrient digestibility of broiler starter chicks fed with different levels of silkworm meal.

Digestibility (%)	Diets[#] (soybean: silkworm)					SEM	Significance[#]
	SM0 (100:0)	SM25 (75:25)	SM50 (50:50)	SM75 (25:75)	SM100 (0:100)		
Dry matter	82.5	82.6	82.5	82.7	82.3	2.87	NS
Crude protein	83.2	81.3	80.2	80.6	79.2.2	3.63	NS
Ether extract	78.7	79.1	80.5	81.3	80.8	3.59	NS
Crude fiber	85.3	84.1	85.2	86.1	85.9	1.97	NS
Ash	49.4	48.5	51.3	52.4	53.3	1.62	NS
N free extract	90.8	92.7	92.6	93.8	94.1	2.02	NS

NS, not significant (P> 0.05)
#SM0is control diet, whereas in the other diets 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) of the soybean meal was replaced with silkworm meal.

Table 8. Organoleptic quality of broiler meat supplemented silkworm meal diets

Diets[#] (SBM:SWM) [†]	Taste (Mean ± SE)	Tenderness (Mean ± SE)	Juiciness (Mean ± SE)	Color (Mean ± SE)	Flavor (Mean ± SE)
SM0 (100:0)	2.31 ± 0.28	2.41 ± 0.23	2.35 ± 0.06	2.45 ± 0.17	2.44 ± 0.55
SM25 (75:25)	2.34 ± 0.16	2.37 ± 0.39	2.33 ± 0.15	2.44 ± 0.26	2.52 ± 0.16
SM50 (50:50)	2.32 ± 0.27	2.37 ± 0.19	2.32 ± 0.14	2.47 ± 0.38	2.53 ± 0.25
SM75 (25:75)	2.41 ± 0.18	2.42 ± 0.13	2.37 ±0.21	2.49 ± 0.22	2.57 ± 0.20
SM100 (0:100)	2.43 ± 0.16	2.39 ± 0.23	2.41 ± 0.26	2.42 ± 0.34	2.48 ± 0.31
P-Value	NS	NS	NS	NS	NS

NS, non significant
[#]SM0is control diet, whereas in the other diets 25% (SM25), 50% (SM50), 75% (SM75) and 100% (SM100) of the soybean meal was replaced with silkworm meal.
[†]SBM, soybean meal; SWM, silkworm meal.

DISCUSSION

The proximate composition indicated that silkworm meal is a rich source of crude protein (57.6%) and crude fat (23.3%). Our findings are within the range of values of crude protein (60.7± 7.0) and crude fat (25.7 ± 9.0) as reported in a recent Meta-analysis (Makkar *et al*., 2014). Recently, Ji *et al*. (2015) reported similar chemical composition for silkworm meal with slight differences. The variation in chemical composition of silkworm meal may be due to differences in the substrate used for its production, stage of harvesting, management conditions and methods of processing and storage (Ojewola *et al*. 2005; Ijaiya and Eko, 2009). Unlike other animal origin feed ingredients, the fat of silkworm has a high content of polyunsaturated fatty acids, notably linolenic acid (18:3n-3), with reported values ranged from 11 to 45% of the total fatty acids (Rao, 1994; Usub *et al*., 2008). As such supplementation of silkworm meal to poultry birds can potentially improve their health and production performance, and benefit long-term human health.

The individual amino acid contents of the silkworm meal reported in the present study are within the range of literature values (Makkar *et al*., 2014; Ji *et al*. 2015; Valerie *et al*., 2015). The amino acid composition (g/100 g of total amino acids) of the silkworm meal indicates that amino acids lysine (7.52 *vs*.6.11) and methionine (3.88*vs*. 1.40) were higher in silkworm meal than soybean meal (Valerie *et al*., 2015). Solomon and Yusufu (2005) and Ji *et al*. (2015) found that the amino acid composition of silkworm meal is close to the amino acids composition of fish meal and superior to soybean meal. Moreover, our study showed that silkworm meal had IGH proportion (51.3%) of essential amino acids. Specifically, in comparison of soybean with silkworm meal it contained higher contents (g/100 g of total amino acids) of the essential amino acids, namely, lysine (7.52), methionine + cystine (4.85), arginine (6.31), phenylalanine (5.58) and valine (5.70). However, the leucine: isoleucine ratio of silkworm (7.04:4.73) was lower than that of soybean meal (7.5: 4.6). The ratio of leucine and isoleucine needs careful consideration in poultry feed formulation because it is often implicated in amino acid antagonism (Crawshaw, 1994). Moreover, the silkworm meal was limiting in tryptophan. The silkworm also showed higher gross energy (4530 ± 81.0 kcal/kg) than soybean meal (2556 kcal/kg) (Hueze *et al*., 2017). The results of present study regarding amino acids profile encourage the replacement of soybean meal with silkworm meal in poultry ration.

Makkar *et al*. (2014) reported that except silkworm meal other insect meals are deficient in lysine and methionine, supplementation of silkworm meal in the diet can enhance both the performance of the animals and can replace both soybean meal and fishmeal in the diet. The improved performance of broilers with the replacement of soybean meal with silkworm meal (up to 75%) could be related to its higher content of essential amino acids, minerals and energy (Khatun *et al*. 2003). Fogoonee (1983) argued that the silkworm meal contain growth prompting factors such as ecdysteroid activity (a hormone involved in protein synthesis and tissue formation), though this has not been confirmed yet. In the present study, highest feed intake, weight gain, dressing percentage and lowest FCR was observed with 75% replacement of soybean meal by silkworm meal. The reasons for best FCR with the 75% replacement level may be due to a more optimal supply of essential amino acid profile (particularly tryptophan), nutrient digestibility and an increased rate of protein accumulation (Khan *et al*., 2016b). Although no direct comparisons could be made due to lack of literature review, Fagoonee (1983), Konwar *et al*. (2008) reported that replacing 50% of the fish meal with silkworm meal in broiler ration supported optimum growth performance and improved the profit margin due to its much lower cost. Moreover, Ijaiya and Eko (2009) reported a higher weight gain with 75% replacement of fish meal with silkworm meal. However, the intake and production performance reduced with 100% replacement of fish meal with silkworm meal (Ijaiya and Eko 2009) which coincide with the findings of our study. The plausible reasons for the depressed performance of the birds with 100% replacement of soybean meal with silkworm meal could be the negative impact of high fat content on intake and the inability of young chicks to utilize the crude fiber inherent in the exoskeleton (made of chitin) of the silkworm caterpillar (Fagoonee1983; Makkar *et al*., 2014; Valerie *et al*., 2015).

Our results are also comparable with the findings of Khatun *et al*. (2003) who observed highest dressing percentage for the dietary groups containing higher level of fish meal replacement with silkworm meal. The result of sensory evaluation parameters such as tenderness, juiciness, color and flavor showed that the inclusion of silkworm meal did not alter these properties as compared to control diet. In contrast, Sun *et al*. (2013) found that broiler chicks reared on the diet containing grasshopper had a negative impact on the sensory quality of the meat. The presence of essential amino acids and polyunsaturated fatty acids in silkworm meal may lead to better sensory scores (Qiao *et al*., 2016), which were observed in the present study. Our results have indicated that the meat quality of broiler produced with the feeding of silkworm meal is acceptable by the consumer.

Conclusions: The results of the present study showed that silkworm is a rich source of crude protein, crude fat and essential amino acids including lysine and methionine. Silkworm meal may be used to replace 75% soybean meal in the broiler starter ration for better performance and dressing percentage without affecting meat sensory quality.

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