Research Article

# Effect of Supplementation of Mealworm Scales (*Tenebrio molitor*) on Growth Performance, Carcass Traits and Histomorphology of Japanese Quails

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**Abstract** | Increased demand for animal protein and high cost as well as shortage of conventional feed ingredients has driven the dire need to search for alternative protein and energy sources to be incorporated in poultry feed. Insects may be one of the alternative feed source which can be used as a good quality, low-cost and sustainable ingredients of poultry feed. Therefore, the present experiment was designed to explore the effect of dietary inclusion of mealworm (*Tenebrio molitor*) scales in diet on production performance, carcass quality and histomorphology of *Coturnix japonica* (Japanese quails). For this, 120 Japanese quail chicks (day-old) were taken and randomly divided into 4 groups (G1, G2, G3 and G4) with three replicates and ten birds were assigned to each replicate. Group 1 was control (C) without adding mealworm scales in feed (basal diet). Group 2, 3 and 4 were fed ration with 1, 2 and 3 g/kg mealworm scales respectively incorporated in the basal feed. Feed intake, FCR (feed conversion ratio) and body weight gain were recorded on weekly basis. The use of mealworm scales at level of 3g/kg in feed significantly (P<0.05) decreased feed intake, increased weight gain and improved feed conversion rate (FCR) as compared to other groups. A significant (P<0.05) increase in crypt depth and villus height of birds was recorded fed diet supplemented with mealworm scales (3g/kg). The breast percent and carcass weight recorded in birds fed 3g/kg mealworm scales in diet was significantly (P<0.05) higher than other groups. In conclusion, data of the current experiment indicated that mealworm (*Tenebrio molitor*) scales at the level of 3g/kg in quail's diet has important effects on performance, carcass traits and histomorphology of ileum.

**Keywords** | Mealworm scales; Japanese quail; Performance; Gut histomorphology

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## INTRODUCTION

A rapid increase in prices of traditional feed resources such as soybean meal, fish and bone meal and their reduced upcoming supply has caused the insects gaining more attraction as a possible alternative poultry feed ingredient (Moula and Detilleux, 2019). In the nature, poultry diet contain insects as a normal component (Nascimento Filho et al., 2021). Chitin from the exoskeleton of insects has been found beneficial to improve immune systems; thus, poultry health could be increased by feeding insects to commercial poultry. Due to high protein (30-70 percent) and fat content (30-40 percent), a couple of insect classes have been suggested as alternate source of sustainable poultry feed (FAO 2019; Olukosi et al., 2019; Gasco et al., 2020). Moreover, high egg production and growth of commercial chicken need higher intake of quality protein (Kermanshahi and Rostami, 2006; Kamran et al., 2004) to fulfill the amino acid supplies especially sulphur-containing amino acids () which are also higher in poultry products (Veldkamp et al., 2012).

Protein sources for poultry feed are mainly plant based and/or animal based (Abrro et al., 2012). Soybean meal and cottonseed are main sources of protein of plant origin used in broiler feed (Anwaar et al., 2008), and the animal sources of protein are meat cum bone meal and fish meal (Ata and Al-Masad, 2015). The yellow mealworm (*Tenebrio molitor*) is a known European insect of grain and cereal products (Raamos et al., 2002). The mealworm (*Tenebrio molitor*) carries a good profile of fat (31-43 percent) and protein (47-60 percent). New mealworm larvae have a dry matter content of 14.5 percent. Some scholars say that insects could be essential for poultry feeding as an optional choice of protein (Raamos et al., 2002; Sancheez et al., 2014; Abbas et al., 2020).

Japanese quail is one of the most effective biological machines for converting feed into animal protein of high biological value (Das et al., 2012; Ali et al., 2012, Mizutaani, 2003). As a source of eggs and meat, these birds are raised. Compared to the various poultry types, Japanese quail has the benefit of fast growth rate, small size, good reproductive ability, short life cycle, low feed requirements, good meat taste, better laying capacity and shorter hatching period (Wakasugii, 1984; Crawforod, 1990; Kaayang et al., 2004; Siyadati et al., 2011).

Recent studies suggested a partial replacement of soybean meal with *T. molitor* larvae meal in poultry diets to improve growth, feed consumption, feed utilization, immunity and health (Kozlowski et al., 2021; Nieto et al., 2022). The mealworm meal has also been reported for additional benefits including the use as antibiotics replacement in livestock and poultry (Stastnik et al., 2021; Sorum and Sunde, 2001). Therefore, the present trial was conducted to examine the effect of supplementation of mealworm scales (*Tenebrio molitor*) on growth performance, carcass traits and histomorphology of Japanese quails.

## MATERIALS AND METHODS

The trial was conducted at The University of Agriculture Peshawar's poultry farm to examine the effect of supplementation of mealworm scales on growth performance, carcass traits and histomorphology of Japanese quails. The pathology laboratory of The FAH (Faculty of Animal Husbandry) and Veterinary Sciences was also used for lab analysis of the research. All experimental protocols were carried out in line with international standard of animal housing and management and were prior approved by the faculty ethical committee for scientific research and animal welfare.

### Birds Management and Feeding of Groups

A total of 120 day-old Japanese quail chicks were purchased from local hatchery for trial. The chicks were kept in brooding environment for one week and after brooding chicks were divided into four groups (G1, G2, G3 and G4) with three replicates and ten birds were assigned to each replicate. Group 1 was control without adding mealworm scales in feed (basal diet). Group 2 was fed basal diet with 1g/kg mealworm scales in feed. Group 3 was fed basal diet with 2g/kg mealworm scales in feed. Group 4 was provided with ration supplemented with 3g/kg mealworm scales. Mealworm scales were tested for its dry matter, crude fat, crude fiber, crude protein and crude ash contents in Animal nutrition laboratory (See Table 1). The composition of the experimental basal diet was formulated according to NRC (1994) to meet the requirements of Japanese quails. Total duration of the trial was 5 weeks and balanced diet was given *ad-libitum* for all groups from day 1 through day 35. Continuous light was provided for 24 hours during the entire trial. Reasonable biosecurity measures were observed during the trial.

**Table 1:** Proximate analysis of mealworm (*Tenebrio molitor*) scales

| Description of Sample | % Dry Matter (Ground) | On Dry Matter Basis | | | |
|---|---|---|---|---|---|
| | | % Crude Protein | % Crude Fiber | % Crude Ash | % Crude Fat |
| Mealworm (*Tenebrio molitor*) Scales | 93.99 | 60.09 | Nil | 3.78 | 3.71 |

### Estimation of performance

Feed given to birds was recorded on daily basis and the actual feed consumption was calculated by subtracting the feed offered from the residue (feed remained). Feed consumption was calculated using the following formula:

Feed intake (gram/bird/day) = Feed offered – Feed refused

Data recorded was converted into weekly data.

Body weight gain (BWG) was observed using digital electronic scale at the end of every week during trial for each group. To calculate the weight gain, initial body weight was subtracted from the final weight on the last day of the week using the formula given below:

Gain in weight = Final Body Weight - Initial Body Weight
Feed conversion rate (FCR) was determined by dividing the total amount of feed consumed by the amount of weight gained. FCR was calculated by the formula as follows:

FCR =

### Carcass traits

At the end of experiment, 3 birds were selected randomly from each replicate to determine the dressed body weight. Prior to slaughtering, all chicks were weighted individually on electronic balance. After slaughtering following a 4 minutes bleeding time the skin was removed manually. Weighing was performed on different edible sections such as the leg, thigh, breast, and wings. Organs including gall bladder, gizzard, heart, lungs, spleen, intestines and bursa were also removed and weighed on a digital balance. The dressing percentage was determined using the formula below:
Dressing percentage = Weight of Carcass / Live Weight x 100

### Gut Morphometry

On day 35, three birds from each replicate were slaughtered to assess villus height using a high-resolution microscope. A 3cm portion of the ileum midpoint was incised, cut and rinsed with normal saline solution before being fixed in buffer formalin. After that, each component was embedded in paraffin and a 2 millimeters portion of each sample was fixed on a glass slide for examination and painted with eosin and hematoxylin. Histological sections were analyzed and tested microscopically. From the top of the villus to the top of the Lamina Propria, the height of the villus was determined. The depth of the crypt was measured from the Villus-Crypt junction to the bottom of the crypt, and an average value of ten fields were recorded for each specimen.

### Statistical Analysis

The experimental data was evaluated using a CRD (complete randomized design) and the results got from the study were statistically analyzed following Steel and Torri, (1996) method. To compare the differences among means the least significant difference test method was used at 5 percent probability level. ANOVA was performed to find the means and standard errors by using software statistical package (STAT-8.1) after arranging data in excel sheet.

## RESULTS AND DISCUSSION

Soybean meal is being criticized these days for its higher price and continual use of high level of soybean as a protein source in poultry diets would be a big setback for enhancing agricultural productivity and economic sustainability (Mnisi and Mlambo, 2018). For least cost and sustainable ration formulation insect meals have been suggested as a substitute of soybean meal as insect production requires less water and land use, resulting in lower greenhouse gas emissions (Selaledi et al., 2020; Sarmiento-García et al., 2021). Insect-derived foods offer a higher biological value than soybeans, with higher protein content (45–70%) and a well-balanced amino acid composition Gasco et al. (2018). Therefore, the present research study was carried out to investigate the effect of supplementation of mealworm scales on growth performance, carcass traits and histomorphology of Japanese quails.

**Table 2:** Effect of supplementation of mealworm scales (*Tenebrio molitor*) on feed intake (g) of Japanese quails.

| Groups | 2nd week | 3rd week | 4th week | 5th week | Overall |
|---|---|---|---|---|---|
| G1 | $82.15^{a}$ ± 0.98 | 110.33 ± 2.45 | $142.37^{a}$ ± 0.98 | $167.41^{a}$ ± 2.15 | $502.10^{a}$ ± 2.07 |
| G2 | $79.02^{b}$ ± 0.57 | 108.05 ± 3.55 | $140.38^{ab}$ ± 1.56 | $166.11^{a}$ ± 2.05 | $494.17^{b}$ ± 2.50 |
| G3 | $78.23^{b}$ ± 1.55 | 105.69 ± 2.96 | $137.57^{bc}$ ± 1.42 | $164.57^{ab}$ ± 1.57 | $486.70^{c}$ ± 1.92 |
| G4 | $76.59^{b}$ ± 1.92 | 103.44 ± 3.36 | $134.61^{c}$ ± 2.45 | $161.83^{b}$ ± 1.19 | $478.46^{d}$ ± 1.79 |
| P value | 0.006 | 0.113 | 0.002 | 0.025 | 0.000 |

Groups: G1 = Control, G2 = 1g/kg mealworm scales in feed, G3 = 2g/kg mealworm scales in feed, G4 = 3g/kg mealworm scales in feed. $^{a-d}$ values not sharing a common superscript in the same column varied significant (P<0.05).

### Feed intake

Table 2 shows the effect of mealworm scales on feed consumption of Japanese quails. Supplementation of mealworm scales significantly (P<0.05) affect the feed intake of Japanese quails. Overall lower feed intake (478.46g) was noted in G4 (3g/kg mealworm scales) while maximum feed intake (502.10g) was noted for G1 (Control). The chitin contents of mealworm meal (*Tenebrio molitor*) probably might reduce the feed palatability which cause the negative effect on quail feed intake as also explained by Bovera et al. (2015). In the present trial feed intake of the quails was decreased with the supplementation of mealworm scales. The results of the present trial are accordant to Loponte et al. (2017) who reported that the addition of *Tenebrio molitor* meal in diet in partridges improved feed intake. The results are also in-line with those described by Liu et al. (2021), Ballitoc. (2013) and Bovera et al. (2015) who reported effects of *Tenebrio molitor* meal supplementation on feed consumption and performance of chicken. However, in contrast to result of the present study Ramos et al. (2002) and Biasato et al. (2016) reported that addition of *Tenebrio molitor* meal in diet did not affect feed intake of chickens. Zadeh et al. (2019) also reported negative effect of *Tenebrio molitor* supplementation on feed intake of Japanese quails. Moreover, Biasato et al. (2017) found that chicks fed *Tenebrio molitor* meal based diets had higher feed intake in comparison to broiler given the basal diet.

**Table 3:** Effect of supplementation of mealworm scales (*Tenebrio molitor*) on body weight gain (g) of Japanese quails.

| Groups | 2nd week | 3rd week | 4th week | 5th week | Overall |
|---|---|---|---|---|---|
| G1 | 26.19[b] ± 0.91 | 35.33 ± 2.45 | 44.22[c] ± 1.10 | 53.44[c] ± 2.42 | 159.06[c] ± 3.97 |
| G2 | 27.10[b] ± 0.93 | 36.34 ± 2.42 | 46.27[bc] ± 1.03 | 55.65[bc] ± 1.48 | 164.78[bc] ± 3.46 |
| G3 | 27.70[ab] ± 0.17 | 38.39 ± 1.38 | 47.53[ab] ± 1.42 | 58.10[ab] ± 1.08 | 171.61[ab] ± 3.44 |
| G4 | 29.13[a] ± 1.08 | 39.29 ± 1.45 | 49.14[a] ± 0.98 | 59.24[a] ± 1.06 | 176.25[a] ± 3.99 |
| P value | 0.017 | 0.133 | 0.004 | 0.009 | 0.002 |

Groups: G1 = Control, G2 = 1g/kg mealworm scales in feed, G3 = 2g/kg mealworm scales in feed, G4 = 3g/kg mealworm scales in feed. [a-c] values not sharing a common superscript in the same column varied significant (P<0.05).

## Weight gain

Table 3 shows the effect of mealworm scales on weight gain of Japanese quails. Mealworm scales (*Tenebrio molitor*) in feed significantly (P<0.05) affect the weight gain of Japanese quails. Overall body weight gain was maximum for G4 (176.25g) followed by G3 (171.61g), G2 (164.78g), while minimum weight gain was noted for group G1 (159.06g). Total mean weight gains of mealworm scales supplemented groups was similar to standard group. Body weight gain was improved with increasing mealworm scales in diet.

Result of the present experiment are compatible with the results of studies reported by Zadeh et al. (2019) and Jabri et al. (2017) as these researchers reported the positive effects of dietary supplementation *Tenebrio molitor* meal on body weight gain of broilers. Likewise, Biasato et al. (2017) reported an improvement in weight gain of chickens offered diets containing *Tenebrio molitor* meal in comparison with those fed the basal diet. Currently, many researches have investigate the effect of supplementation of mealworm on growth performance, carcass traits and histomorphology in poultry species (Benzertiha et al., 2020; Sedgh-Gooya et al., 2021; Bellezza Oddon et al., 2021; Nascimento Filho et al., 2021). Elahi et al. (2020) also reported that dietary dried mealworm meal quadratically and linearly increased the starter body weight gain. Findings of the current experiment are contrary with Ramos et al. (2002) and Biasato et al. (2016). They reported that inclusion of *Tenebrio molitor* meal in the range of 50 to 100 g/kg of ration did not affect weight gain of chickens, respectively. Similarly some other researchers (Marareni and Mnisi, 2020; Maurer et al., 2016; Biasato et al., 2016; Cullere et al., 2018; Elahi et al., 2020) also reported negative effect of dietary addition of various insects meal on weight gain of broilers. However, the differences in results might be due to varying nutritional composition of these meals varies by species, rearing condition and life stage which could account for the vast range of observed outcomes (Zadeh et al., 2019).

**Table 4:** Effect of supplementation of mealworm scales (*Tenebrio molitor*) on feed conversion ratio of Japanese quails.

| Groups | 2nd week | 3rd week | 4th week | 5th week | Overall |
|---|---|---|---|---|---|
| G1 | 3.13[a] ± 0.10 | 3.12 ± 0.25 | 3.19[a] ± 0.12 | 3.12[a] ± 0.11 | 3.17[a] ± 0.16 |
| G2 | 2.92[b] ± 0.06 | 2.96 ± 0.15 | 3.02[ab] ± 0.07 | 3.01[ab] ± 0.10 | 2.90[ab] ± 0.19 |
| G3 | 2.82[bc] ± 0.08 | 2.79 ± 0.28 | 2.89[bc] ± 0.11 | 2.84[bc] ± 0.08 | 2.83[b] ± 0.11 |
| G4 | 2.66[c] ± 0.10 | 2.65 ± 0.16 | 2.75[c] ± 0.02 | 2.76[c] ± 0.10 | 2.75[b] ± 0.10 |
| P value | 0.001 | 0.121 | 0.002 | 0.010 | 0.037 |

Groups: G1 = Control, G2 = 1g/kg mealworm scales in feed, G3 = 2g/kg mealworm scales in feed, G4 = 3g/kg mealworm scales in feed. [a-c] values not sharing a common superscript in the same column varied significant (P<0.05).

## Feed conversion ratio

Table 4 shows overall and weekly feed conversion ratio of experimental groups. The results shows that mealworm scales (*Tenebrio molitor*) improved weekly and overall mean FCR in Japanese quails. Overall FCR was maximum (poor) for group G1 (Control) (3.17) followed by G2 (2.90) and G3 (2.83). Overall minimum (good) FCR was recorded for group G4 (2.75). In the current trial FCR was improved with increasing mealworm scales inclusion up to 3g/kg in diet.

The results of the current study are similar to results of a study conducted by Zadeh et al. (2019) who observed that feed conversion ratio of the broilers was improved by increasing *Tenebrio molitor* meal addition up to 30 g/kg level in diet. Similar results are also reported by Ballitoc and Sun (2013) and Bovera et al. (2015) who investigated positive effects of inclusion of *Tenebrio molitor* meal in chicken's diet on FCR. However, in contrast to the current result Biasato et al. (2017) noted that supplementing chickens feed with *Tenebrio molitor* meal negatively affect FCR. Similarly, Ramos et al. (2002) also reported that inclusion of *Tenebrio molitor* meal with in a range of 50 to

**Table 5:** Effect of supplementation of mealworm scales (*Tenebrio molitor*) on carcass traits of Japanese quails.

| Groups | Carcass Weight g | Carcass Dressing % | Breast % of Carcass | Back % of Carcass | Legs % of Carcass | Wings % of Carcass | Neck % of Carcass | Heart % of live weight | Liver % of live weight |
|---|---|---|---|---|---|---|---|---|---|
| G1 | 125.46$^{c}$ ± 2.43 | 63.89$^{c}$ ± 1.67 | 32.36$^{b}$± 1.43 | 23.34$^{b}$± 1.50 | 16.33± 1.49 | 11.04± 1.98 | 9.65± 1.16 | 1.48± 1.36 | 2.20± 1.74 |
| G2 | 128.37$^{bc}$± 2.38 | 65.23$^{bc}$ ± 0.66 | 34.38$^{b}$± 1.42 | 24.37$^{b}$± 1.49 | 18.03± 1.98 | 12.02± 1.93 | 8.02± 1.76 | 1.36± 0.98 | 2.08± 1.22 |
| G3 | 130.47$^{ab}$± 1.46 | 66.73$^{ab}$ ± 0.64 | 37.32$^{a}$± 1.38 | 26.35$^{ab}$± 2.42 | 19.02± 1.92 | 12.13± 1.95 | 6.49± 1.68 | 1.86± 1.08 | 2.21± 1.50 |
| G4 | 133.33$^{a}$± 1.39 | 68.62$^{a}$ ± 1.57 | 39.47$^{a}$± 1.27 | 29.45$^{a}$± 1.46 | 21.13± 1.83 | 14.05± 1.97 | 9.83± 0.78 | 1.53± 1.33 | 2.30± 1.57 |
| P value | 0.007 | 0.008 | 0.001 | 0.012 | 0.063 | 0.360 | 0.061 | 0.960 | 0.998 |

Groups: G1 = Control, G2 = 1g/kg mealworm scales in feed, G3 = 2g/kg mealworm scales in feed, G4 = 3g/kg mealworm scales in feed. $^{a-c}$values not sharing a common superscript in the same column varied significant (P<0.05).

100 g/kg of feed did not affect FCR performance of chicken. Similarly, Marareni and Mnisi (2020) also reported negative effect of varying insects meals in the diet on FCR of broilers. Since increased gut growth such as longer villi and deeper crypts can lead to increased nutrient absorption perhaps the insect meal have some nutrients linked to increased gut development and hence better nutrient absorption which ultimately resulted in better FCR of the birds fed *Tenebrio molitor* scales meal based diets (Kavyani et al., 2014; Liu et al., 2021).

## Carcass traits

Carcass traits of the birds supplemented with mealworm scales in feed of growing quails are presented in Table 5. Supplementation of mealworm scales did not affect (P>0.05) wings weigh, leg weight, neck weight, heart weight and liver weight of experimental birds however it significantly (P<0.05) affect the carcass dressing percentage, carcass weight, back percentage of carcass, and breast percentage of carcass. In case of carcass weight, maximum carcass weight was noted for group G4 followed by G3 and G2, while minimum carcass weight was recorded for G1. Similarly, mealworm supplementation in feed affect (P>0.05) the legs percent and neck percent and was recorded maximum for group G4 followed by groups G3 and G2 and minimum was noted for group G1.

Findings of the current study are similar to Zadeh et al. (2019) who noted that the carcass yield obtained from birds which were provided diet containing 30 g/kg insect meal was significantly (P < 0.05) higher than those fed *Tenebrio molitor* as a substitute of meal of fish at levels of 7.5, 15 and 22.5 but were not differed from the birds fed the basal diet. The results support the work of Hwangbo et al. (2009), Ballitoc and Sun (2013) and Khatun et al. 2003 who determined that supplementation of insect meal in chicken diets increased slaughter, dressed carcass, thigh muscle weights, breast muscle and dressing percentage. Effects of use of *Hermetia illucens* larvae meal has also been reported to improve production performance, egg characteristics, oxidative status and yolk fat profile of laying hens (Liu et al., 2021). Also Biasato et al. (2017) found that liver percentage and gizzard percentage in broiler chicks fed varying quantities of *Tenebrio molitor* meal was unaffected. Results of the current study are varied to Marareni and Mnisi (2020) who noted that dietary addition of insect meal found to be influenced on carcass quality and organ weights of quail birds. Similarly Zadeh et al. (2019) and Elahi et al. (2020) investigated that addition of meal of insect, as a replacement of soybean meal did not affect the relative carcass characteristics and organs weights.

**Table 6:** Effect of supplementation of mealworm scales (*Tenebrio molitor*) on the morphometry of ileum of Japanese quails.

| Groups | VH (µm) | CD (µm) | VW (µm) | VH:CD (µm) |
|---|---|---|---|---|
| G1 | 367.68$^{c}$± 6.47 | 126.38$^{b}$± 6.48 | 105.00$^{a}$± 0.40 | 3.43± 0.81 |
| G2 | 377.36$^{bc}$± 7.71 | 131.34$^{b}$± 7.42 | 96.36$^{b}$± 0.79 | 3.68± 0.99 |
| G3 | 387.99$^{ab}$± 7.48 | 138.35$^{ab}$± 7.99 | 103.24$^{a}$± 0.35 | 4.04± 1.01 |
| G4 | 399.03$^{a}$± 7.16 | 146.38$^{a}$± 6.97 | 108.47$^{a}$± 1.00 | 5.13± 0.85 |
| P value | 0.003 | 0.043 | 0.004 | 0.196 |

Groups: G1 = Control, G2 = 1g/kg mealworm scales in feed, G3 = 2g/kg mealworm scales in feed, G4 = 3g/kg mealworm scales in feed. $^{a-c}$values not sharing a common superscript in the same column varied significant (P<0.05). VH: Villus height, CD: Crypt depth, VW: Villus width, VH: CD: Villus height Crypt depth ratio

## Intestinal histomorphology

Morphometry of intestinal ileum of the birds supplemented with mealworm scales in feed of growing quails are presented in Table 6. Morphometry of intestine of the birds supplemented with mealworm scales in feed of growing quails was affected significantly (P<0.05). The results showed significant (P<0.05) increase in villus height (VH) and villus width (VW) and crypt depth (CD) whilst the difference was found non-significant (P>0.05) for Villus Height Crypt depth ratio (VH: CD). With the increasing amount of mealworm scales VH and VW was found to be increased. Zadeh et al. (2019) reported that growing quails fed 22.5 and 30 g/kg mealworm in diet had significantly (P<0.05) higher VH and lower VW than those fed the basal diet, and a basal diet supplemented with 7.5 g/kg of diet. Biasato et al. (2017) reported that *Tenebrio molitor* meal inclusion did not influence the gut morphology of the broiler chickens. Biasato et al. (2018) also investigated efficacy of different levels of *Tenebrio molitor* (TM) meal as a replacement for soybean meal and oil (0, 50, 100 and 150 g TM/kg of diet) and found positive effect of *Tenebrio molitor* meal on GIT of birds. The discrepancy between the results of present study and previous experiments could be related to the lower doses used in the present trial.

## CONCLUSIONS

From the findings of the current study it is concluded that supplementation of mealworm (*Teneberio molitor*) scales may cause a decrease in feed intake, improve feed conversion ratio (FCR), improve weight gain of broiler and also helpful to improve the carcass traits, carcass yield and morphology of ileum. Based upon the present study an inclusion of 3g/kg of mealworm scales is more efficient as compared to lower inclusion levels (1% and 2%). However further research is needed to explore the effect of further higher dietary levels of *Teneberio molitor* scales meals on production performance of broiler.

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## CONFLICT OF INTEREST

Authors of this article declare no confliction of interest.

## NOVELTY STATEMENT

The *Teneberio molitor* scales meal was successfully used in quails diets which led to improve the production performance, carcass characteristics and GIT morphomtery of broiler. Hence the results of the research are beneficial to promote the nonconventional feed resources for environmental friendly production. This work is original and results can be implemented on industrial and commercial scale.

## AUTHORS CONTRIBUTION

Sarzamin khan, Rafiullah and Ibrahimullah designed, executed and conducted the study. Ghulam Abbas and Abdul Jabbar Tanweer interpreted the data, and wrote the manuscript. Jabbar Khan, Muhammad Saeed Imran, and Asghar Ali Kamboh revised the manuscript for necessary intellectual contents. All authors approved the final manuscript.

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