RESEARCH ARTICLE

Effect of Dietary Incorporation of *Moringa oleifera* Leaf Meal on Growth Performance and Nutrient Utilization of Japanese Quail

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Abstract

A feeding trial was conducted to discern the influence of dietary incorporation of *Moringa oleifera* leaf meal on growth performance and nutrient utilization of Japanese quail for 6 weeks. A total 288 day-old Japanese quail chicks were randomly distributed into eight treatments of 36 Japanese quail chicks per treatment with three replicates of 12 quail in each. Japanese quail of treatment T_1 (control group) were fed a basal diet (starter and finisher), whereas in treatment group T_2 basal diet was incorporated with Vitamin C @200 mg/kg, T_3 basal diet was incorporated with Vitamin E @10 IU/kg, and in diets T_4, T_5, T_6, T_7, and T_8, the basal diet was incorporated with 1.0%, 3.0%, 5.0%, 7.0% and 9.0% *Moringa oleifera* leaf meal, respectively. Results showed that incorporation of 3.0% *Moringa oleifera* leaf meal improved the performance of Japanese quail in terms of body weight gain and performance index during the overall period. The maximum crude protein utilization was seen in 3.0% *Moringa oleifera* leaf meal incorporated group of Japanese quail followed by 1.0%. However, maximum ether extract utilization was seen with 1.0% *Moringa oleifera* leaf meal while ether extract and crude protein utilization was lower in 9.0% *Moringa oleifera* leaf meal incorporated group. Average feed cost per kg weight gain differed in Japanese quail offered various dietary treatment. It can be concluded that 3.0 % *Moringa oleifera* leaf meal can be incorporated in feed for improvement in growth performance of Japanese quail.

Key words: Growth performance, Japanese quail, *Moringa oleifera* leaf meal and Nutrient utilization.

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Introduction

Animal protein is essential and indispensible for the ever growing population of India to make healthy human resources. India ranks 8th in the world in terms of total meat production. The meat production from poultry is 4.995 million tonnes, contributing about 51.14% of total meat production. The growth of poultry meat production has increased by 4.52% over previous year (BAHS, 2023). Commercial quail farming is becoming more popular and is being increasingly promoted in number of Asian and European countries and in Africa (RSPCA, 2011). Quail meat is renowned for their high-quality protein, and low caloric content (Agiang *et al.,* 2011). Many meat consumers prefer quail meat because of its low fat content, primarily saturated fatty acid (Boni *et al.,* 2010). According to Genchev *et al.* (2008), a daily intake of two quails provides the human body with 27-28 g protein, 11 g of essential amino acids, and covers 40% of the human protein requirement. Feed costs account about 65-70% of total cost in poultry production (Oladokun and Johnson, 2012). With the increasing population and growing demand, there will be acute shortage of major feed ingredients, maize and soybean in near future (Thirumalaisamy *et al.,* 2016). As a result, it has become necessary to evaluate alternative plant sources especially for protein, among which are the leaf meals (Siddiqui *et al.,* 2022).

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Moringa oleifera commonly called as "*Miracle trees*" or drumstick tree is well known in tropical and sub-tropical regions. *Moringa* leaves are rich in crude protein (24-29%) content and can be utilized as feed supplement for poultry

(Su and Chen, 2020). Incorporation of *Moringa oleifera* leaf meal in the diet of poultry may improve the performance in terms of growth, nutrient utilization and enhance the health status of birds. So, the present study was planned to investigate the effect of dietary incorporation of *Moringa oleifera* leaf meal (MOLM) on growth performance, and nutrient utilization of Japanese quail.

Materials and Methods

The study was conducted for 6 weeks at Instructional Poultry Farm, GBPUAT, Pantnagar during winter season of February 2022. A total number of 288-day-old chicks of Japanese quail, as approved by the Institutional Animal Ethics Committee (IAEC), were randomly distributed into eight treatment groups. Each treatment comprised of three replicates consisting of 12 Japanese quails per replicate. For the experiment, two types of basal diets were prepared to meet the nutrient requirement of Japanese quail, *i.e.,* starter (0-3 weeks) and finisher (3-6 weeks) as per ICAR (2013). The eight dietary treatments were T_1 (Basal diet), T_2 (Basal diet with vitamin C @ 200 mg/kg), T_3 (Basal diet with vitamin E @ 10 IU/kg), T_4 (Basal diet with 1% MOLM), T_5 (Basal diet with 3% MOLM), T_6 (Basal diet with 5% MOLM), T_7 (Basal diet with 7% MOLM) and T_8 (Basal diet with 9% MOLM). The feeding trial was carried out for a period of 6 weeks. A metabolism trial was conducted in the last week of the feeding trial for 7 days to assess nutrient utilization in which twelve Japanese quail were randomly selected from each treatment. Japanese quail were reared in a cage system using standard management and health care practices. The cost of feed was calculated considering the actual market prices of the feed ingredients and feed additives used in preparation of Japanese quail starter and finisher feeds.

Nutrient Composition of *Moringa oleifera* Leaf Meal and Experimental Diets

The required quantity of *Moringa oleifera* (Sahjan) leaves were air-dried in the shade, followed by drying in a hot air oven at 60°C for 3 to 4 days, and then finely ground to powder using a laboratory mill and stored in a closed and dry container and then mixed with basal feed at varying levels. *Moringa oleifera* leaf meal contained 92.40% organic matter, 22.47% crude protein, 9.67% ether extract, 12.14% crude fibre, 7.6% total ash, 48.13% nitrogen free extract, 1.13% acid insoluble ash and 60.26% total carbohydrate on dry matter basis. The dry matter, crude protein, ether extract, crude fiber, total ash, and nitrogen-free extract content for the Japanese quail's starter feed were 91.76, 25.49, 3.43, 5.76, 6.35, and 58.97%, respectively, and finisher feed were 92.38, 21.76, 3.78, 4.98, 5.13 and 64.35% respectively.

Parameters Studied

Feed offered was recorded daily, and body weight was recorded replicate-wise weekly for 6 weeks. Further, weekly feed intake, body weight gain, feed conversion ratio (FCR), and performance index for each treatment group were calculated. Nutrient utilization by the Japanese quail chicks was estimated from the results of proximate analysis of feed samples and samples of droppings collected in the metabolism trial.

Statistical Analysis

The data obtained were analyzed statistically by applying One way ANOVA using SPSS software version 21 (Snedecor and Cochran, 1994). The significant mean differences were calculated by Duncan's post-hoc analysis with a significance level of $p<0.05$.

Results and Discussion

Production Performance

The average production performance of Japanese quails in terms of feed intake, body weight gain, feed conversion ratio, and performance index of different groups during the feeding trial are presented in Table 1.

During starter phase (0-21 days) a significantly ($p<0.05$) higher weight gain was obtained in T_5 group as compared to control and lower in T_8 group. Significantly ($p<0.05$) higher feed intake was noticed in T_2 group as compared to control and lower in T_3 group. Significantly ($p<0.05$) most efficient value of feed conversion ratio was seen in Japanese quail chicks of T_4 (1% MOLM) group which was better than T_1 (control) group. Significant ($p<0.05$) difference of performance index was found in between T_2 and T_4 group.

During the finisher phase (22-42 days) of the feeding trial, maximum and significantly ($p<0.05$) higher feed intake was recorded in T_5 (3% MOLM) and lower in T_8 (9% MOLM) treatment group. Non-significant ($p>0.05$) differences were observed in body weight gain among Japanese quail chicks of different treatment groups during this period. Statistically maximum body weight gain was observed in T_5 and minimum in T_8 group. Non-significant ($p>0.05$) differences were observed in FCR among Japanese quail chicks of different treatment groups during this period. The performance index for the finisher phase was maximum and significantly ($p<0.05$) higher in T_5 group and lower in T_8 (9% MOLM) as compared to control.

During the whole feeding trial period (0-42 days) the cumulative average body weight gain of T_5 group was significantly ($p<0.05$) higher followed by T_4, while significantly ($p<0.05$) lower weight gain was seen in T_8 group. Significantly ($p<0.05$) higher feed intake was recorded in T_5 group and lower in T_8 group as compared to control group. It was noted that MOLM incorporation in treatment group improved the FCR values but the differences among the values were non-significant. Most efficient value of FCR was noted in T_4 followed by T_1, T_3 and T_5 groups, respectively.

The present findings are in accordance with the report of Baloch *et al.* (2021), who noticed maximum broiler chicken body weight in 2.5% MOLM supplemented group as compared to other treatment groups. Furthermore Banjo (2012) and Teteh

Table 1: Effect of *Moringa olifera* leaf meal (MOLM) on weekly growth performance of Japanese quail

Parameters	Treatment/Groups							
	T_1 (Basal diet)	**T_2** (Basal diet with Vitamin C @ 200 mg/kg)	**T_3** (Basal diet with Vitamin E @10 IU/kg)	**T_4** (Basal diet with 1% MOLM)	**T_5** (Basal diet with 3% MOLM)	**T_6** (Basal diet with 5% MOLM)	**T_7** (Basal diet with 7% MOLM)	**T_8** (Basal diet with 9% MOLM)
Starter Phase (0-21 days)								
Weight gain (g)	65.35 ± 1.62^{b}	66.49 ± 0.49^{ab}	66.14 ± 1.12^{ab}	67.54 ± 0.48^{ab}	68.48 ± 0.58^{a}	66.07 ± 0.49^{ab}	65.96 ± 0.57^{ab}	64.88 ± 0.47^{b}
Feed intake (g)*	173.82 ± 6.11^{bcd}	186.48 ± 3.53^{a}	167.99 ± 2.31^{d}	174.68 ± 0.18^{bcd}	180.73 ± 1.24^{ab}	173.56 ± 1.25^{bcd}	179.04 ± 4.15^{abc}	169.72 ± 3.05^{cd}
FCR*	2.66 ± 0.03^{bc}	2.80 ± 0.04^{a}	2.54 ± 0.07^{c}	2.58 ± 0.02^{bc}	2.63 ± 0.2^{bc}	2.62 ± 0.02^{bc}	2.71 ± 0.04^{ab}	2.62 ± 0.05^{bc}
Performance index	24.57 ± 0.37^{ab}	23.71 ± 0.13^{b}	26.08 ± 1.26^{a}	26.11 ± 0.38^{a}	25.95 ± 0.33^{a}	25.16 ± 0.44^{ab}	24.31 ± 0.28^{ab}	24.83 ± 0.67^{ab}
Finisher Phase (21-42 days)								
Weight gain (g)*	164.39 ± 1.39^{a}	161.87 ± 1.13^{a}	160.39 ± 1.88^{a}	167.25 ± 2.13^{a}	169.06 ± 2.04^{a}	158.02 ± 3.77^{a}	156.37 ± 1.84^{a}	141.54 ± 10.08^{b}
Feed intake (g)*	520.53 ± 4.95^{cde}	533.53 ± 1.74^{abc}	517.17 ± 1.73^{de}	535.74 ± 2.40^{ab}	544.90 ± 1.17^{a}	529.86 ± 9.95^{bcd}	521.61 ± 2.15^{bcde}	509.18 ± 4.04^{e}
FCR	3.16 ± 0.04^{b}	3.29 ± 0.02^{ab}	3.22 ± 0.04^{b}	3.20 ± 0.02^{b}	3.22 ± 0.04^{b}	3.36 ± 0.12^{ab}	3.34 ± 0.04^{ab}	3.64 ± 0.27^{a}
Performance index*	51.93 ± 1.06^{a}	49.12 ± 0.65^{a}	49.76 ± 1.32^{a}	52.21 ± 1.09^{a}	52.47 ± 1.38^{a}	47.24 ± 2.65^{a}	46.89 ± 1.21^{a}	39.74 ± 5.44^{b}
Whole Feeding Trial (0-42 days)								
Weight gain (g)*	229.73 ± 1.26^{ab}	228.36 ± 1.23^{ab}	226.52 ± 0.89^{ab}	234.78 ± 2.50^{ab}	237.54 ± 2.50^{a}	224.09 ± 3.32^{b}	222.32 ± 1.32^{b}	206.42 ± 9.61^{c}
Feed intake (g)*	749.64 ± 8.38^{bcd}	765.95 ± 2.93^{ab}	731.50 ± 2.51^{de}	756.19 ± 4.68^{abc}	770.66 ± 1.32^{a}	744.84 ± 11.97^{cd}	732.88 ± 2.92^{de}	716.51 ± 4.04^{e}
FCR	3.26 ± 0.03^{ab}	3.35 ± 0.01^{ab}	3.22 ± 0.02^{b}	3.22 ± 0.02^{b}	3.24 ± 0.03^{b}	3.32 ± 0.08^{ab}	3.29 ± 0.03^{ab}	3.48 ± 0.16^{a}
Performance index*	70.41 ± 0.75^{a}	68.08 ± 0.51^{a}	70.15 ± 0.79^{a}	72.90 ± 1.29^{a}	73.23 ± 1.50^{a}	67.49 ± 2.40^{a}	67.45 ± 1.05^{a}	59.72 ± 5.42^{b}

Means bearing different superscript in a row differ significantly at $p<0.05$.

Table 2: Effect of *Moringa olifera* leaf meal (MOLM) on nutrient utilization (%) of Japanese quail

Parameters	Treatment/Groups							
	T_1 (Basal diet)	T_2 (Basal diet with Vitamin C @ 200 mg/kg)	T_3 (Basal diet with Vitamin E @10 IU/kg)	T_4 (Basal diet with 1% MOLM)	T_5 (Basal diet with 3% MOLM)	T_6 (Basal diet with 5% MOLM)	T_7 (Basal diet with 7% MOLM)	T_8 (Basal diet with 9% MOLM)
Dry matter	66.78 ± 1.84^{ab}	66.35 ± 1.74^{ab}	67.03 ± 3.32^{ab}	65.96 ± 1.69^{ab}	67.39 ± 1.41^{a}	64.92 ± 1.58^{ab}	67.90 ± 0.93^{a}	61.26 ± 0.58^{b}
Organic matter	68.03±1.77	68.13±1.92	69.03±3.11	67.94±1.59	69.42±1.31	66.61±1.56	69.41±1.04	63.53±0.54
Crude protein*	70.86 ± 1.58^{ab}	70.23 ± 2.34^{ab}	69.75 ± 2.39^{ab}	71.28 ± 0.45^{ab}	74.32 ± 0.70^{a}	64.88 ± 4.32^{bc}	63.81 ± 3.49^{bc}	58.44 ± 3.16^{c}
Ether extract*	76.73 ± 1.29^{a}	76.64 ± 1.43^{a}	77.71 ± 2.57^{a}	79.07 ± 1.03^{a}	78.66 ± 0.92^{a}	76.05 ± 1.82^{a}	76.83 ± 0.75^{a}	69.91 ± 0.45^{b}
Total carbohydrate	61.65 ± 0.72^{ab}	66.16 ± 1.91^{a}	60.67 ± 2.01^{ab}	64.09 ± 1.43^{a}	64.69 ± 1.47^{a}	62.38 ± 1.54^{ab}	62.35 ± 2.38^{ab}	58.46 ± 0.98^{b}

Means bearing different superscript in a row differ significantly at $p<0.05$.

Table 3: Economics of Japanese quail chicks fed diets incorporated with *Moringa olifera* leaf meal at 42[th] days of age

Parameters	Treatment/Groups							
	T_1 (Basal diet)	T_2 (Basal diet with Vitamin C @ 200 mg/kg)	T_3 (Basal diet with Vitamin E @10 IU/kg)	T_4 (Basal diet with 1% MOLM)	T_5 (Basal diet with 3% MOLM)	T_6 (Basal diet with 5% MOLM)	T_7 (Basal diet with 7% MOLM)	T_8 (Basal diet with 9% MOLM)
Average BW gain (g/b)*	229.73 ± 1.26^{ab}	228.36 ± 1.22^{ab}	226.52 ± 0.89^{ab}	234.78 ± 2.50^{ab}	237.54 ± 2.50^{a}	224.09 ± 3.32^{b}	222.32 ± 1.32^{b}	206.42 ± 9.61^{c}
Average feed intake/bird (g)*	749.64 ± 8.36^{bcd}	765.95 ± 2.93^{ab}	731.51 ± 2.51^{de}	756.18 ± 4.68^{abc}	770.66 ± 1.32^{a}	744.84 ± 11.97^{cd}	732.88 ± 2.92^{de}	716.51 ± 4.04^{e}
Feed cost/kg (Rs.)*	23.22 ± 0.01^{a}	23.22 ± 0.01^{a}	23.22 ± 0.01^{b}	22.33 ± 0.01^{bc}	21.46 ± 0.01^{c}	20.78 ± 0.01^{d}	19.78 ± 0.01^{e}	18.56 ± 0.01^{f}
Total feed cost (Rs./bird)*	17.40 ± 0.19^{a}	17.78 ± 0.06^{a}	16.98 ± 0.05^{b}	16.89 ± 0.10^{bc}	16.54 ± 0.02^{c}	15.48 ± 0.24^{d}	14.49 ± 0.05^{e}	13.30 ± 0.07^{f}
Feed cost/kg weight gain (Rs.)*	101.08 ± 0.55^{a}	101.68 ± 0.54^{a}	102.51 ± 0.40^{a}	95.15 ± 1.02^{b}	90.39 ± 0.95^{bc}	92.80 ± 1.37^{bc}	88.97 ± 0.53^{c}	90.33 ± 4.33^{bc}

Means bearing different superscript in a row differ significantly at $p<0.05$

et al. (2013) mentioned that the inclusion of 1% MOLM in the diet of the broilers significantly ($p<0.05$) enhanced their weight gain than the control. Similarly Talukdar *et al.* (2020) noticed the higher body weight in 0.25% and 0.50% MOLM incorporated diet of Japanese quails. Furthermore, Hamad *et al.* (2018) noticed the higher body weight in MOLM at level of 6 g/kg diet of Japanese quail as compared to control group. The improved weight gain of quail could be attributed to high digestibility of *Moringa oleifera* leaves which could improve absorption of nutrients (Backer, 1995).

In the present study, a significant ($p<0.05$) decline in weight gain and feed intake was noted in Japanese quail that received 7.0% and 9.0% MOLM in diet during overall growth period. The adverse effect on growth rate in birds can be attributed to the presence of higher crude fibre content which may impair nutrient digestion and absorption (Onu and Aniebo, 2011). Another reason for reduction in feed intake at higher level of inclusion of MOLM in diet could be due to reduced palatability of the diet and presence of anti-nutritional factor like tannin (Kakengi *et al.*, 2003).

In the present study, significant ($p<0.05$) improvement in FCR was found in Japanese quail, received 1.0% MOLM in diet during overall growth period. The present result is in line with the finding of Karthivashan *et al.* (2015) who observed that 1.5% of *Moringa oleifera* leaf meal extract gave the best FCR as compared to other treatments in broiler diets. In contrast, El-Tazi (2014) noticed that broilers fed on 5% MOLM diet showed best and significantly ($p<0.05$) higher FCR in birds. This improvement in FCR may be attributed to rich content of nutrients in *M. oleifera* (Kakengi *et al.*, 2003). The present study showed a significant ($p<0.05$) improvement in performance index of quail that received lower doses of *Moringa oleifera* leaf meal (1.0 and 3.0%) in diet during overall growth period. These findings were in accordance with the report of Hamad *et al.* (2018), who reported that quail fed diets supplemented with 6 g/kg MOLM showed higher performance index as compared to control.

The present study revealed significant ($p<0.05$) improvement in average weight gain, feed intake, feed conversion ratio in Japanese quail that received vitamin C (200 mg/kg) and vitamin E (10 IU/kg) in diet as compared to control during overall growth period. Similarly Abudabos *et al.* (2018) reported significantly ($p<0.05$) increased performance in broilers in terms of body weight gain and feed intake with supplementation of vitamin C @ 200 mg/L in the drinking water. In contrast, Bushwereb *et al.* (2023) observed that the addition of vitamins C and E had no impact on the growth efficacy in broilers.

Nutrient Utilization

The average values of nutrient utilization of Japanese quail in terms of dry matter, crude protein, ether extract, organic matter, and total carbohydrate in different treatment groups during the metabolism trial are presented in Table 2.

There were insignificant variations in the utilization of dry matter, organic matter and total carbohydrate in the Japanese quail fed diet incorporated with varying levels of *Moringa oleifera* leaf meal. The significant ($p<0.05$) value of crude protein utilization was seen in Japanese quail of group T_5 (3% MOLM) followed by T_4 (1% MOLM), and T_1 treatment group. However significantly ($p<0.05$) maximum values of ether extract utilization was seen in T_4 (1% MOLM) group followed by T_5 and T_3 treatment group and lower values of ether extract and crude protein utilization were seen in T_8 treatment group. The results of the study are in accordance with Fouad and Raye (2019), who noted that birds provided 7 g MOL/kg in diet had the best digestibility of nutrients compared with other dietary treatments. Likewise Harshini *et al.* (2022) observed inclusion of MOL powder (5%, 10%, and 15%) to the basal diet in birds had no significant ($p>0.05$) variation in the apparent digestibility of nutrients and the reduction in feed intake of supplemented groups did not affect their retention of nutrients. Furthermore Prakash *et al.* (2022) noticed supplementation of neem leaf powder (0.25%, 0.50%, and 1.00%) to the basal diet had no significant ($p>0.05$) variation in the utilization of dry matter, crude protein, ether extract, and organic matter in the Japanese quail.

The present study showed a significant ($p<0.05$) influence in nutrient utilization of Japanese quail received vitamin C and E in diet. These results agreed with Sahin *et al.* (2001), who reported the digestibility of dry matter, organic matter, crude protein, ether extract as greater with higher dietary vitamin C ($p<0.05$) and also with higher vitamin E. Furthermore Sahin *et al.* (2002) reported that heat exposure decreased digestibility of dry matter, organic matter, crude protein and ether extract, which were elevated by supplemental vitamin E.

Economics over Feed Cost

The results of economic analysis (Table 3) indicated significant ($p<0.05$) differences in average feed cost per kg weight gain in Japanese quail offered varying level of *Moringa oleifera* leaf meal in diet. These findings were in agreement with the Zanu *et al.* (2012), who indicated that cost benefit analysis in broiler chickens with incorporation of MOLM (5, 10, and 15%) resulted in reduced feed cost. Similarly Onibi *et al.* (2008) reported a reduction in the cost of feed consumed at higher inclusion of MOLM.

Conclusion

Based on the findings of this study, it can be concluded that 3% *Moringa oleifera* leaf meal can be incorporated in feed for improvement of growth performance of the Japanese quail.

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