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Original Article

Efficacy of Tulsi (Ocimum Sanctum) Plant Powder on Health, Growth and Carcass Traits of Japanese Quail (Coturnix Japonica)

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■Keywords

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ABSTRACT

The objective of the current work was to assess the effects of Tulsi plant powder on the health, growth and carcass characteristics of Japanese quail. In total, 300 quails (1-week old) were distributed into four treatment groups with five replicates each. The first group (T0) was a control group where a basal standard diet was offered to the birds. Groups T0.5, T1 and T1.5 were supplemented with Tulsi plant powder at a rate of 0.5%, 1%, 1.5%, respectively. Data were analyzed in SPSS software by applying one-way ANOVA and significant and notable means were analyzed through Duncan's New Multiple Range Test. Dietary supplementation of T1.5 significantly ($p \leq 0.05$) increased the feed intake, body weight, gain in weight and presented a better feed conversion ratio. Significantly higher glucose, total cholesterol, HDL, WBCs, RBCs and HCT were observed in the quails from T1 than in the control group ($p \leq 0.05$). However, the quails from T1.5 had significantly ($p \leq 0.05$) higher hemoglobin, MCV, platelets and total protein contents. On the other hand, the T0 group was only higher in LDL contents. Non-significant ($p > 0.05$) in MCH, MCHC, triglyceride, VLDL were noted among the experimental groups. It was concluded that the dietary supplementation of Tulsi plant powder at 1.5 % is beneficial for improving the growth performance and can be used in the diet of Japanese quail without compromising the health status and carcass traits.

INTRODUCTION

Poultry production is playing a vital role in producing meat and eggs within a short time for a huge global population. Globally, broiler chickens are produced and slaughtered in thousands of tons on a daily basis. However, the consumers' concerns about meat quality issues and use of antibiotics and synthetic supplements in the diet are the major attributes that shifted the attention of the consumer to purchase the meat from alternative species such as Japanese quail (Bhujbal *et al*., 2009; Ghayas *et al*., 2017; Ghayas *et al*., 2020). Japanese quail is one of the preferred species for farming among poultry producers due to its beneficial characteristics of fast growth, early maturity, short generation interval and more disease resistance. Nutritional supplements are used to increase the growth performance, livability, to reduce the mortality rate and to achieve better feed conversion efficiency in poultry birds (Singh & Panda, 1992). The European Union has banned antibiotics usage in poultry diets to overcome the issues of residues in meat (Khanna & Bhatia, 2003).

There are many non-remedial replacements of these antibiotics such as enzymes, herbs, probiotics and inorganic acids (Banerjee, 1998). Among these, herbal supplements are more beneficial and have little or no side effects on the animals' performance. From ancient times the herbs and

their medicinal properties have been known for their versatility level of antimicrobial activity. Most herbs have antibacterial, anti-virus, anti-inflammatory, or especially antioxidant properties. Therefore, their inclusion in the diet should be encouraged to improve the performance of this bird, improve feed consumption, maintain health and reduce the negative effects of environmental stress. These herbal supplements can be considered as herbal growth promoters and are gaining interest in animal feeding due to the prohibition of artificial antibiotic growth promoters (Juven *et al*., 1994; Borris, 1996; Vinus *et al*., 2018).

Tulsi (*Ocimum Sanctum*) is a popular herb in the sub-continent region and belongs to the family *Lamiaceae*. In tropical and subtropical areas, it is being utilized as a medicine for malaria, cure of bronchitis, chronic fever, bronchial asthma, diarrhea, dysentery, arthritis, skin infection, painful eye infection and many others (Singh *et al*., 2014). In poultry, Tulsi has been used with variable results. In broilers, growth performance was reported to be affected by the dietary supplementation of Tulsi in the diet (Hasan *et al*., 2016). In another study, total feed intake and final body weight were not influenced by the adding of Tulsi to the diet of broiler chickens that ultimately led to the comparable feed conversion ratio (Gohel *et al*., 2019). Similarly, in another experiment, carcass traits including the dressing percentage, and the internal body organs like the weight of the heart, gizzard, spleen and pancreas were non-significantly different between broilers fed diets supplemented with or without Tulsi leaves (Nath *et al*., 2012). However, there is no information presently available to the quail farmers about the usage of dietary usage of Tulsi leaves. This work is an effort to conclude the effect of Tulsi leaves in quails' diet on the growth, health, carcass traits and blood biochemical and hematological parameters.

MATERIALS AND METHODS

Tulsi Plant Powder

Fresh Tulsi plant powder was directly purchased from a herbal medicine shop named Pak Herbal medicine shop located at Pappar Mandi, Lohari Gate Lahore, Pakistan. Firstly, the Tulsi plant was sun dried for 2 days and then a powder was made with the Tulsi plant using a grinding machine and stored it for later use.

Experimental site and experimental strategy

The study was accompanied at the Avian Research and Training Center (ARTC) of the University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan. A total of 300 one week old quails (mixed sex) were reared until the birds reached the age of 35 days in an octagonal shed from the end of October to the end of November. The experimental quails were procured from the hatchery of ARTC from an already maintained breeder flock under project number HEC-NRPU-8352. The quail chicks were initially weighed and divided into four treatment groups (75 chicks per group) according to the Completely Randomized Design. Each group was replicated five times and each replicate had 15 quail chicks. The first group (T0), was the control group, where the quails were fed with the normal standard diet. The second group (T0.5) was offered a feed containing Tulsi leaves powder at a rate of 0.5 percent in the diet. In the third group (T1), Tulsi leaves powder was included at a rate of 1% in the diet. The fourth and last group was fed with 1.5% of Tulsi leaves in the basal diet. The diet was formulated and manufactured at a commercial feed processing plant. The composition and formulation of the experimental diet are shown in Table 1.

Table 1 – Composition of experimental diet.

Ingredients	Control	Tulsi 0.5%	Tulsi 1%	T 1.5%
Broken rice	20	20	19	19.5
Corn	35.36307	34.86404	35.36667	34.36667
Tulsi powder	0	0.5	1	1.5
Raw rice bran	4	4	4	4
Soybean meal 44%	25.99907	25.99907	25.99907	25.99907
Sunflower meal	7.660067	7.660067	7.660067	7.660067
Rape seed	4	4	4	4
DL-Methionine	0.259667	0.259667	0.259667	0.259667
L-Threonine	0.131867	0.131867	0.131867	0.131867
Calcium carbonate	0.2754	0.2754	0.2754	0.2754
Salt	0.277	0.277	0.277	0.277
Bone Ash	0.94	0.94	0.94	0.94
Lysine Suphate	0.54	0.54	0.54	0.54
*Premix	0.3	0.3	0.3	0.3
Bicarb	0.23	0.23	0.23	0.23
Quantum 1000ftu	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00e67
Crude protein (%)	21.89	21.88	21.88	21.88
M.E (Kcal / Kg)	3035.23	3034.98	3033.78	3033.70
Lysine	1.29	1.30	1.29	1.30
Calcium	0.91	0.90	0.90	0.88
Available Phosphorus	0.46	0.45	0.43	0.44

*Premix contained Vit-A 9000 I.U, Vit-D 3250 I.U, Vit-E 30 I.U, Vit-K3 4mg, Thiamine 3.5mg, Riboflavin 8mg, Vit-B6 4.4 mg, Vit-B12 1.5 mg, Folic Acid 1mg, Vit-B5 12 mg, Niacin 55 mg, Biotin 5 mg, Choline Chloride 700 mg, Selenium 50 mg, Zinc 110 mg, Copper 67.2 mg, Iron 394 mg, Manganese 172 mg, Potassium Iodide 0.8 mg, Furazolidon 100 mg, Maduramycin 50 mg.

Management of the experimental birds

The experimental birds were reared in custom made broiler quail cages. The birds were provided *ad-libitum*

feed-in tube feeders and water was provided through mechanical nipple lines placed inside the cages. The house temperature and humidity were 26 to 29 °C and 65 to 75% respectively. Due to cold weather, the electric bulbs were installed inside the cages to maintained the Temperature of the birds in the sheds for the 1st week. No vaccination and medication practice was carried out throughout the experimental period.

Growth performance

A measured amount of feed was offered on a daily basis and the feed refusal was recorded on an interval of 24 hours regularly by using an electronic weighing balance with an accuracy of 0.01 grams. Daily feed intakes were calculated by subtracting the feed refusal from the amount of feed offered. The daily data were converted into average weekly figures by using a factor of 7. The bodyweight (g/bird) of the experimental groups was determined by weighing the birds of each replicate and then dividing the total number of birds in that replicate. Initial and final body weights were further used to derive the weight gain (g/bird). The weekly gain in weight and weekly feed intake was used to calculate the weekly feed conversion ratio (FCR) by using the following equation.

$$Feed\ conversion\ rate = \frac{total\ feed\ consumption}{increased\ weight}$$

Carcass traits

At the age of 35 days, three quails per replicate were randomly selected and deprived of feed for eight hours to ensure the emptiness of the crop of the quails. The pre-slaughter weight of each quail was noted. Later, the quails were slaughtered following the Halal Islamic method. Briefly, the jugular vein of the quail was severed by a sharp knife while reciting the Holy verses of Takbeer, followed by allowing the severed bird to bleed for 3 to 5 minutes. After the bleeding stopped completely, the quails were de-feathered and eviscerated manually and their carcasses were weighed. The effect of Tulsi leaves powder on the internal organs was also assessed by recording the weights of the liver, gizzard and heart. The viscera weight (Liver, Gizzard and Heart weight) was measured on a digital weight balance and then their values were converted into relative weights of each organ by following the formulas as follows:

Relative Liver weight:

$$Relative\ weight\ of\ Liver = \frac{weight\ of\ Liver}{Body\ weight}$$

Relative Gizzard weight:

$$Relative\ weight\ of\ Liver = \frac{weight\ of\ Gizzard}{Body\ weight}$$

Relative heart weight:

$$Relative\ weight\ of\ Liver = \frac{weight\ of\ Heart}{Body\ weight}$$

Blood hematology and biochemical profile

In total, 60 birds (three quails/replicate) were selected. Carcass analysis was done and blood was collected at the time of slaughtering, as discussed above. Two milliliters of blood from the Jugular vein of each bird were collected in an anti-coagulant added vacutainer. Thereafter, blood samples were subjected to centrifugation at 4000 revolutions per minute for 10 minutes and the supernatant liquid was separated in Eppendorf tubes as serum. The collected serum was stored at -20°C for biochemical tests. For serum biochemistry, blood glucose, triglycerides, total protein, cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, VLDL cholesterol and for Hematological assessment, Hematological parameters: Hemoglobin, (WBCs) White Blood Cells, Total (RBCs) Red Blood Cells, (HCT) Hematocrit value, (MCV) Mean Corpuscular Volume, (MCH) Mean Corpuscular Hemoglobin, (MCHC) Mean Corpuscular Hemoglobin Concentration and Platelets examination were carried out at Quality Lab, Specialized Laboratory Services, Jail Road, Lahore. Hematological parameters were measured using the Sysmex XP100 Hematology analyzer. For biochemical parameters (cholesterol, glucose, triglycerides, total proteins, HDL, LDL and VLDL) an automatic Beckman Coulter Analyzer was used (Young, 1997).

Ethical Approval

The ethical approval was approved by the Research Ethical Committee IMBB-The University of Lahore with reference letter number or Ethical agreement number (IMBB/UOL/20/137).

Statistical Analysis

The collected data analysis was done via one-way ANOVA (Steel *et al*., 1997) in SPSS software. The results from significant means of treatments were compared through Duncan's New Multiple range test (Duncan, 1955).

Regression analysis

To evaluate the impact of varying percentages of Tulsi on the study or response variables under consideration, a simple linear regression $Y = \alpha + \beta X$

was run. Here Y denotes study or response variable, α stands for the intercept and signifies the value of the response variable when Tulsi was not added in the diet of the chicks, β denotes the regression coefficient and measures the change occurring in the response variable for every 1 percent change in the percentage of Tulsi, and X symbolizes the independent variable Tulsi added in the diet of the chicks. The resulting estimates of α and β, their associated standard errors (SEs), *p*-values, 95% lower confidence limits (LCL) and 95% upper confidence limits (UCL) were reported in Table 6.

RESULTS

Growth performance

Mean values of body weight, weight gain, feed intake and feed conversion ratio are presented in Table 2. Supplementation of Tulsi leaves significantly ($p \leq 0.05$) affected the feed consumption of Japanese quail. The highest feed intake was recorded in the quails that were fed Tulsi leaves at a rate of 1.5%. Although all the Tulsi supplemented groups showed a higher feed intake than the control group, these did not differ among themselves. The initial body weight showed that control, T0.5, T1 and T1.5 were 21.72 g, 21.90 g, 21.72 g, and 21.82 g respectively without any significant difference ($p>0.05$) among the treatment groups. While the final body weights of control, T0.5%, T1% and T1.5% were 186.20 g, 203.12 g, 220.24 g and 235.52 g, respectively and showed significant differences ($p \leq 0.05$) among the treatment groups.

In the case of weight gain, there were significant differences ($p \leq 0.05$) among the experimental groups. Results showed that the body weight gain increased with an increase in the inclusion rate of the Tulsi leaves. The highest weight gain was observed in Tulsi 1.5% (213.70 g) group followed by T1% (198.52), T0.5% (181.22), Control (164.47).

Dietary treatments of Tulsi leaves in Japanese quail have shown a significant impact on FCR. The better FCR was noted in the groups of quails fed the Tulsi leaves diet at a rate of 1.5% in the diet.

Table 2 – Feed intake, bodyweight, weight gain and feed conversion ratio of Japanese quail supplemented Tulsi powder.

Variable		Control	Tulsi 0.5%	Tulsi 1%	Tulsi 1.5%	*p*-Value
Feed intake (n=75)	g/bird	619.38^{b}±6.29	655.91^{a}±7.31	667.68^{a}±8.57	677.68^{a}±8.53	0.00
Initial Bodyweight (n=75)		21.72±0.13	21.90±0.12	21.72±0.11	21.82±0.10	0.68
Final Bodyweight (n=75)		186.20^{d}±3.20	203.12^{c}±1.68	220.24^{b}±4.22	235.52^{a}±5.42	0.00
Weight gain (n=75)		164.47^{d}±3.25	181.22^{c}±1.69	198.52^{b}±4.19	213.70^{a}±5.37	0.00
FCR (n=75)		3.76^{a}±0.10	3.62^{b}±0.07	3.36^{c}±0.56	3.18^{d}±0.11	0.00

Different alphabets within a row show significant differences.

Carcass traits

Table 3 shows the carcass characteristics of Japanese quail. There was no significant effect ($p>0.05$) of Tulsi leaves supplementation on all the carcass parameters that were: pre-slaughter weight, post-slaughter weight, dressed weight and the relative weight of liver, relative weight of gizzard and the relative weight of heart of Japanese quails.

Table 3 – Carcass Characteristics of Japanese quail supplemented Tulsi powder.

Carcass Characteristics (Age of analysis= at 35 days) Control		Treatment				*p*-Value
		Tulsi 0.5%	Tulsi 1%	Tulsi 1.5%		
Live Weight	(g)	191±3.93	194±6.37	199±6.71	214±10.82	0.17
Slaughter Weight		178±3.45	181±7.54	186±6.43	201±9.16	0.12
Dressed weight		112±3.77	112±4.93	112±2.94	121±6.95	0.49
Relative Liver		2.50±0.29	2.24±0.11	2.39±0.09	2.53±0.21	0.682
Relative Gizzard		2.88±0.24	3.08±0.25	3.03±0.182	2.96±0.21	0.932
Relative Heart		0.91±0.07	0.96±0.02	1.10±0.05	0.93±0.03	0.064

Different alphabets within a row show significant differences.

Hematological assessment

Table 4 shows the blood hematological parameters of Japanese quail fed with or without Tulsi leaves in the diet. There was a non-significant difference ($p>0.05$) in MCH and MCHC values but hemoglobin, WBCs, RBCs, HCT, MCV, and platelets were significantly different ($p \leq 0.05$) among the Treatment groups of Japanese quails.

Blood biochemical profile

Mean values of blood biochemistry of Japanese quails fed the diet supplemented with Tulsi are

Table 4 – Hematological assessment of Japanese quails fed with Tulsi leaves in the diet.

Blood parameters	Treatment				*p*-Value
	Control (n=15)	Tulsi 0.5% (n=15)	Tulsi 1% (n=15)	Tulsi 1.5% (n=15)	
Hemoglobin (g/dL)	11.82^{c}±0.22	12.62^{bc}±0.42	12.90^{b}±0.22	14.76^{a}±0.30	0.00
WBC (x10^{3}/uL)	2.56^{a}±5.42	2.19^{b}±0.60	2.59^{a}±0.96	2.28^{b}±6.93	0.00
Total RBC (x10^{6}/uL)	2.68^{b}±0.08	2.60^{b}±0.04	2.98^{a}±0.06	2.66^{b}±0.02	0.00
HCT (PVC%)	45.38^{bc}±1.27	43.20^{c}±0.73	51.80^{a}±0.73	47.00^{b}±0.44	0.00
MCV (fL)	168.80^{b}±0.83	164.80^{b}±1.77	174.20^{a}±1.65	175.20^{a}±1.55	0.00
MCH (pg)	42.40±3.90	45.20±0.37	49.40±1.46	48.60±0.67	0.11
MCHC (g/dL)	31.40±3.91	27.40±0.40	28.40±0.87	27.40±0.24	0.47
Platelets (×103 /µL)	9.80^{a}±1.15	4.56^{b}±1.52	13.20^{a}±1.93	10.00^{a}±1.14	0.00

Different alphabets within a row show significant differences.

shown in Table 5. Non-significant differences (p>0.05) were observed in triglycerides and VLDL while the significant difference (p≤0.05) in glucose, total cholesterol, HDL, LDL and total protein contents were observed in treatment groups. In our study, higher total cholesterol, HDL and LDL contents were found in the T1 group compared to the control group.

Table 5 – Blood biochemical profile of Japanese quail supplemented with Tulsi powder.

Blood parameters	Treatment				*p*-Value
	Control (n=15)	Tulsi 0.5% (n=15)	Tulsi 1% (n=15)	Tulsi 1.5% (n=15)	
Glucose (mg/dL)	97.20^{a}±2.37	85.40^{ab}±12.16	80.80^{ab}±5.06	64.60^{b}±4.85	0.03
Cholesterol (mg/dL)	202.40^{b}±15.05	237.20^{ab}±22.18	307.29^{a}±32.09	228.80^{b}±19.42	0.03
Triglycerides (mg/dL)	221.60±64.17	124.60±7.01	199.20±37.43	179.00±24.36	0.37
HDL (mg/dL)	110.20^{b}±3.30	138.40^{ab}±12.80	169.20^{a}±18.33	128.80^{ab}±16.84	0.05
LDL (mg/dL)	96.00^{b}±3.54	123.40^{b}±10.19	165.40^{a}±22.50	119.00^{b}±10.46	0.01
VLDL(mg/dL)	43.00±11.80	23.80±0.86	41.20±7.33	35.20±4.73	0.28
Total Protein (g/dL)	6.44^{a}±0.10	6.14^{bc}±0.09	6.38^{ab}±0.10	6.00^{c}±0.03	0.00

Different alphabets within a row show significant differences.

Regression Analysis of Growth performance, Carcass and blood parameters

In Table 6, it was observed that for the response variable feed intake being zero percent of Tulsi used in the diet, the feed intake in the chicks totals 627.16 (g) with a 95% confidence limits (590.95, 663.37). Whereas, the amount of feed intake increases by 37.33 grams for every 1 percent increase in the amount of Tulsi with a 95% confidence limits (-1.38, 76.05). Moreover, the estimated value of intercept was statistically significant (p=0.00) and the regression coefficient for feed intake was statistically insignificant (p=0.05). The estimates associated with other study variables may similarly be interpreted. It was further added that all the intercepts associated with the study variables are statistically significant except those of platelets, triglycerides, LDL and VLDL, and the regression coefficients of all the study variables were insignificant except those pertaining to final bodyweight, weight gain, FCR and glucose.

An increase in the percentage of Tulsi caused a decrease in FCR, WBC, MCHC, glucose, triglycerides, VLDL and total protein, but an increase in the rest of the variables.

DISCUSSION

Growth performance

The present study first revealed that feed intake was higher in Tulsi supplemented groups compared to the control group. Similarly, Hasan *et al*. (2016) concluded that dietary supplementation of Tulsi increased the feed consumption in comparison with the control group. Body weight is the most revealing and important factor in selection and production as well as animal performance as a whole (Raji *et al*., 2008). In the current study, the body weight was increased by dietary supplementation of Tulsi at different levels, however the highest body weight was shown by Tulsi 1.5% which ultimately showed better growth performance and provided better meat production than other groups. Similarly, a previous study reported a higher body weight in Tulsi 0.5% supplemented group compared to the control (Vasanthakumar *et al*., 2013; Gohel *et al*., 2019) Another researcher, reported that

Table 6 – Estimates of regression analysis based on all the underlying response variables parameters of the study.

Response Variables	Intercept (α)					Regression coefficient (β)				
	Estimtes	SEs	p-values	LCL	UCL	Estimtes	SEs	*p*-values	LCL	UCL
Feed intake	627.16	8.42	0.00	590.95	663.37	37.33	9.00	0.05	-1.38	76.05
Initial Bodyweight	21.77	0.09	0.00	21.39	22.15	0.02	0.09	0.82	-0.38	0.43
Final Bodyweight	186.51	0.56	0.00	184.12	188.90	33.02	0.59	0.00	30.46	35.57
Weight gain	164.73	0.58	0.00	162.22	167.24	33.00	0.62	0.00	30.31	35.68
FCR	3.78	0.03	0.00	3.66	3.90	-0.40	0.03	0.01	-0.53	-0.27
Live Weight	188.40	3.70	0.00	172.46	204.34	14.80	3.96	0.06	-2.24	31.84
Slaughter Weight	175.40	3.70	0.00	159.46	191.34	14.80	3.96	0.06	-2.24	31.84
Dressed weight	110.20	2.92	0.00	97.65	122.75	5.40	3.12	0.23	-8.01	18.81
Relative Liver weight	2.38	0.13	0.00	1.82	2.94	0.05	0.14	0.76	-0.55	0.65
Relative Gizzard weight	2.96	0.09	0.00	2.59	3.33	0.04	0.09	0.72	-0.36	0.43
Relative Heart weight	0.95	0.08	0.01	0.58	1.31	0.04	0.09	0.70	-0.35	0.43
Hemoglobin (g/dL)	11.66	0.42	0.00	9.86	13.46	1.82	0.45	0.06	-0.11	3.75
WBC (x103/uL)	2.47	0.20	0.01	1.63	3.32	-0.09	0.21	0.72	-0.99	0.82
Total RBC (x106/uL)	2.68	0.17	0.00	1.95	3.41	0.06	0.18	0.76	-0.71	0.84
HCT (PVC%)	44.83	3.29	0.01	30.66	58.99	2.69	3.52	0.52	-12.45	17.83
MCV (fL)	166.46	3.24	0.00	152.52	180.40	5.72	3.46	0.24	-9.19	20.63
MCH (pg)	42.98	1.36	0.00	37.13	48.83	4.56	1.45	0.09	-1.70	10.82
MCHC (g/dL)	30.30	1.28	0.00	24.78	35.82	-2.20	1.37	0.25	-8.10	3.70
Platelets (×103 /µL)	8.00	3.46	0.15	-6.86	22.87	1.85	3.69	0.67	-14.05	17.74
Glucose (mg/dL)	97.36	2.81	0.00	85.28	109.44	-20.48	3.00	0.02	-33.39	-7.57
Cholesterol (mg/dL)	221.53	41.41	0.03	43.36	399.70	29.86	44.27	0.57	-160.61	220.33
Triglycerides (mg/dL)	189.08	41.93	0.05	8.67	369.49	-10.64	44.82	0.83	-203.50	182.22
HDL (mg/dL)	123.66	22.52	0.03	26.77	220.55	17.32	24.07	0.55	-86.26	120.90
LDL (mg/dL)	109.30	25.73	0.05	-1.42	220.02	22.20	27.51	0.50	-96.17	140.57
VLDL (mg/dL)	36.70	8.85	0.05	-1.36	74.76	-1.20	9.46	0.91	-41.89	39.49
Total Protein	6.40	0.16	0.00	5.73	7.07	-0.22	0.17	0.32	-0.93	0.50

the body weight was increased by the supplementation of Tulsi at a rate of 0.5% and 1% in the basic diet in comparison to the control group (Lanjewar *et al*., 2009). Antimicrobial and anti-protozoal properties of Tulsi leaves might be the reason for this rise in body weight (Hasan *et al*., 2016; Khatun *et al*., 2013). The antioxidant properties of the compounds found in Tulsi could be the reason for higher body weight by supplementation of Tulsi. The proper growth of the body increases when the oxidative stress of birds is reduced which ultimately leads to more bodyweight of the birds. This is supported by Kelm *et al*. (2000) who found that Tulsi has numerous compounds (eugenol, rosmarinic acid, carnosol, apigenin ursolic acid, cirsilineol and cirsimaritin). These compounds have revealed strong anti-oxidant properties as well as an anti-inflammatory activity which is helpful for improving body weight. Probably, an increase in the final body weight in successive weeks of age was the reason for higher weight gain in Tulsi fed birds.

The present study revealed that higher weight gain was observed in Tulsi supplemented group. Similarly, the same results were found by Hasan *et al*. (2016) who reported a higher weight gain in broilers supplemented with 2% Tulsi leaves in drinking water than a control group. In another study, supplemented Tulsi at 0.5% and 1% and a combination with Fenugreek (Trigonella foenum graecum l.) at 0.25% Tulsi leaf powder + 0.25% fenugreek seed powder and 0.5% Tulsi leaf powder + 0.5% fenugreek seed powder significantly improved the body weight gain of broilers (Prajapat *et al*., 2018). The present results are also matched with those reported by Gohel *et al*. (2019) who conducted a research experiment on chicken broilers by feeding Tulsi leaves extract at different ratios alone and in combination with *Aloe vera* showing higher weight gain.

The present study revealed the best FCR observed in Tulsi supplemented groups compared to the control group. Earlier to this, better feed efficiency in Tusli fed birds was reported in various experiments (Mazhar *et al*., 2007; Carmona-Fernandez *et al*., 2009; Sheoran *et al*., 2017). Improvement in FCR can be attributed to the enhanced weight gain in Tulsi fed quails. The overall growth performance showed the positive impact of Tulsi supplementation on the quail performance and the outlook seems to be in the favor of quail farmers in terms of less feed consumption and higher weight gain that can ultimately lead to higher profit to them.

Carcass traits

The present study revealed no significant impact of Tulsi supplementation on carcass traits except heart weight. Earlier to this, Hasan *et al*. (2016) reported no effect of Tulsi on the dressing percentage and relative gizzard weight. The present findings are similar to past reports of Nath *et al*. (2012) where Tulsi leaves as a supplement showed a non-significant (p>0.05) impact on dressing percentage, relative heart weight, relative gizzard weight, and the relative liver weight of broilers. However, the present study revealed the non-significant results of the heart among treatment groups but numerically increased value of the heart weight was shown by supplementation of Tulsi. This is matched with the conclusion of Hasan *et al*. (2016) who explained the existence of higher relative heart weight in broilers fed with Tulsi leaves compared to the control group. The higher heart weight of the Tulsi-fed birds could be more beneficial in terms of more ability to withstand the heat stress. More development of the heart can be related to more ability to cope with oxidative stress during the harsh climatic conditions when the birds are more prone to heat stress and have to breathe at a higher rate. Contrary to our findings, Prajapat *et al*. (2018) reported non-significant differences in relative heart weight of broiler from the control group and those fed with Tulsi leaves in the diet.

Hematological assessment

The present study revealed that Tulsi supplementation has a positive influence on some hematological parameters of Japanese quails. Previous studies showed similar results with significantly higher values of RBCs (Hasan *et al*., 2016). Dwivedi *et al*. (2015) reported that the supplementation of *Nigella sativa* increases hemoglobin, PCV, and Total Leucocyte concentration values in broilers. An increase in WBCs and Platelets in Tulsi supplemented groups suggest that the Tulsi leaves were helping the quails' cellular immune organs to enhance the immunity levels against infectious diseases. This has been earlier reported that Tulsi improved immune responses which might be due to the immunostimulatory effect of eugenol and other essential oils present in Tulsi (Sen, 1993; Singh & Doley, 2014).

Blood biochemical profile

The present study revealed that biochemical parameters except triglycerides and VLDL were significantly different compared to the control by supplementation of Tulsi at a different level. Similarly, no effect of Tulsi leaves on triglyceride contents is agreed with Raju *et al*. (2019) who reported no change in triglyceride contents upon the supplementation of various herbal treatments. Higher glucose in the control group compared to those fed with Tulsi leaves is agreed with the findings of Rai *et al*. (1997) who found blood glucose contents in glycemic patients. In another study, Halim & Mukhopadhyay (2006) reported an increase in HDL and LDL contents in rats with experimentally induced diabetes. Contrary to the present findings of higher total cholesterol levels by Tulsi supplementation, Lanjewar *et al*. (2009) reported that Tulsi leaves supplementation at 1% in the diet for seven weeks may result in decreasing the total cholesterol level in the broiler.

CONCLUSION

Tulsi is a beneficial herb that has a positive impact on the overall growth performance of Japanese quail. Adding Tulsi leaves powder at a rate of 1.5% in the diet of quail can enhance the body weight, weight gain and FCR without compromising carcass yield. Additionally, the hematological and biochemical parameters are improved with the addition of Tulsi leaves powder. It was concluded that Tulsi leaves powder can be added at a rate of 1.5% to quails' diet.

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