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EFFECT OF DIETARY APPLE PEEL SUPPLEMENTATION ON GROWTH PERFORMANCE, FEED UTILIZATION AND PRODUCTION TRAITS OF JAPANESE QUAIL

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Abstract

The study was conducted in the main campus of Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Uthal, Balochistan. Day old Japanese Quails (n=120) were randomly divided into four groups (A, B, C and D). Each group was further divided into three (03) replicates having ten (10) birds. The standard rearing management (temperature, humidity, light) of the birds were maintained throughout the study period consisting of twenty-eight (28) days. Apple peel was mixed with other diet ingredients. Four experimental rations having same energy and nitrogen contents having different apple peel levels (3%, 6% and 9%) were formulated and fed to groups A, B, C and D, respectively. Group D was served as control which was prepared with zero inclusion of apple peel. Results revealed that group D took maximum feed intake (268.53 g/b) followed by group C (259.6 g/b) and B (253.22 g/b),

respectively. The minimum feed intake was observed in group A (245.4 g/b). group D drink maximum water intake (537.06 ml/b) followed by group C (519.2 ml/b) and B (506.44 ml/b), respectively. The minimum water intake was observed in group A (490.8 ml/b). Group C received maximum body weight (141.43 g/b) followed by group B (132.43 g/b) and A (124.88 g/b), respectively. The minimum body weight was observed in group D (110.24 g/b). Group C received minimum FCR (1.84) followed by group B (1.91) and A (1.97), respectively. The maximum FCR was observed in group D (2.44). Group C received maximum carcass weight (111.43 g/b) followed by group B (102.43 g/b) and A (94.88 g/b), respectively. The minimum carcass weight was observed in group D (80.24 g/b). Group C received maximum dressing (78.78%) followed by group B (77.34%) and A (75.97%), respectively. The minimum dressing was observed in group D (72.78%). Furthermore, blood profile of Japanese quail shows that maximum total protein concentration was determined in group C (52.86 mg/L) followed by group B (51.32 mg/L) and A (47.55 mg/L), respectively. The minimum total protein concentration was determined in group D (43.82 mg/L). Maximum total lipids concentration was determined in group C (457.21 mg/L) followed by group B (443.81 mg/L) and A (436.55 mg/L), respectively. The minimum total lipids concentration was determined in group D (428.51 mg/L). Maximum total cholesterol concentration was determined in group D (4.32 mmol/L) followed by group A (3.32 mmol/L) and B (3.29 mmol/L), respectively. The minimum total cholesterol concentration was determined in group C (3.15 mmol/L). Maximum blood glucose concentration was determined in group D (3.86 mmol/L) followed by group B (3.27 mmol/L) and A (2.24 mmol/L), respectively. The minimum blood glucose concentration was determined in group D (1.44 mmol/L). Maximum blood calcium concentration was determined in group D (2.92 mmol/L) followed by group B (2.61 mmol/L) and A (2.43 mmol/L), respectively. The minimum blood calcium concentration was determined in group D (2.35 mmol/L). Maximum blood phosphate concentration was determined in group D (5.31 mmol/L) followed by group B (5.23 mmol/L) and A (5.16 mmol/L), respectively. The minimum blood phosphate concentration was determined in group D (4.88 mmol/L). It was concluded that birds feeding with apple peel 9% obtained highest body weight gain, carcass weight and showed the maximum blood profile.

INTRODUCTION

Poultry sector is one of the most vibrant subsectors of the livestock sector. The current investment in Poultry Industry is more than Rs 700 billion. This industry is progressing at an impressive growth rate of 8 percent per annum over last few years. Pakistan has become the 11th largest poultry producer in the world with the production of 1,163 million broilers annually. This sector provides employment (direct/indirect) to over 1.5 million people. Poultry today has been a balancing force to keep a check on the prices of mutton and beef. Poultry meat contributes 35 percent to 1,657 thousand tonnes of the total meat production of 4,708 thousand tonnes in the country. Poultry meat production showed a growth rate of 9.1 percent whereas egg production showed a growth of 5.6 percent to 20.0 billion Nos. during 2019-20 as compared to previous year GDP (GOP, 2019-20).

In poultry production business, feeding is the most expensive input. It accounts for about 65 - 70% of the total cost of production. Apple peel is an alternative feedstuff for animal feeding which can be sourced from local apple market stands and apple processing industry. Apple is rich in Potassium and low in Sodium thus highly recommended for people with high blood pressure (Bamgbose *et al.,* 2015). Apple pericarp (peel) had been treated for poultry use in order to remove or lower the anti-nutritional factors, this includes using different treatment techniques like addition of ash and covering for 3-5 days, sun drying for 4-5 days, oven dried for 2hrs at 100 °C and use of different alkali and sodium hydroxide amongst others (Silas *et al.,* 2014). Apple peel contains higher crude fibre, ash and low crude protein compared to the mesocarp (pulp) and this makes it a good alternative feedstuff for animal feeding (Maina *et al.,* 2012).

In Pakistan poultry industry has largely developed during last two decades. In order to rear chickens for meat purpose, a huge capital is required in term of shelter, feed, vaccine, medication etc. (Hameed *et al.,* 2002; Khaliq et al., 2024). However, quail farming requires less capital as well as shelter, feed, vaccination and medication. Among all these factors feed amounts to about 70% of total cost of production. So, important factor is to produce most economical poultry production through balance and cost in effective ration. Whereas quail farming in our homeland is becoming a popular business, considered to be more profitable, many small farmers are switching over to quail farming. With small initial investment, one can start a quail farm either in specific location or in his house. Dressed quail meat fetches a reasonable market price ranging from Rs.14 to 25 per bird. Steam roasted are precious item of hotels and restaurants, because quail meat has a definite game bird flavour and reputed to be very tasty tender and delicious with high calorific and low cholesterol value. To obtain accurate results, it is necessary to formulate balanced ration. The major components of feed are energy and protein. The amount of feed intake by quails depends upon the metabolizable energy (ME) content in diet, age of bird, its reproductive status and ambient temperature.

The apple pericarp contains some anti-nutritional factors like tannins, oxalate and phytate amongst others which could induce adverse effects like depressive growth, reduced feed efficiency and vital organs damage in the body which may ultimately lead to mortality in birds and great losses in poultry enterprise if good processing techniques to detoxify these anti-nutritional factors are not carried out. Considering the importance of apple peel, this study was therefore designed to evaluate the growth of Quails by feeding apple peel in our local conditions.

MATERIALS AND METHODS

The study on "effect of feeding different levels of apple peel on growth performance, dressing percentage and blood profile of growing Japanese Quail" was conducted in the main campus of Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Uthal, Balochistan. The details are described below.

Feeding trial

Day old Japanese Quails (n=120) was obtained from private farm, Karachi. The birds were randomly dived into four groups (A, B, C and D) after recording initial weight. Each group was further divided into three (03) replicates having ten (10) birds. The standard rearing management (temperature, humidity, light) of the birds were maintained throughout the study period consisting of twenty-eight (28) days. Enough apple was provided from market wastes in which apples were manually processed and dried through sun. After fine milled, the apple peel was mixed with other diet ingredients. Four experimental rations having same energy and nitrogen contents (1, 2, 3 and 4) having different apple peel levels (Table-1) were formulated and fed to groups A, B, C and D, respectively. The Diet-4 was served as control which was prepared with zero inclusion of apple peel. The respective experimental diets (Table-1) and water for each group were made available as an *adlibitum*.

Chemical analysis of feed

The ingredients samples of all experimental diets were evaluated for chemical profile in the Animal Nutrition laboratory of LUAWMS and Sindh Agriculture University, Tandojam before final fixation of

protein levels and other nutrients of all diets. The proximate analyses of feed (dry matter, ash, crude protein, crude fiber and ether extract) were determined using standard procedures (AOAC, 2000).

Table 1: Ingredients composition, Apple Peel levels and other chemical profile of experimental rations %

Ingredients (%)	Ration-1 (3% Apple peel)	Ration-2 (6% Apple peel)	Ration-3 (9% Apple peel)	Ration-4 (0% Apple peel)
Corn grain	42	40	39	42
Rice tips	6	6	4	6
Rice Polish	8	8	7	8
Rice bran	0	0	0	2
Wheat bran	1	1.5	1	2.5
Molasses	1	1	1	1
Apple peel	**3**	**6**	**9**	**0**
Soybean meal	15	15	15	15
Canola meal	3	3	3	3
Corn gluten meal 60	11	11	11.5	11
Fish meal	9	9	9	9
Sunflower meal	0	0	0	0
DCP	0	0	0	0
Ca. carbonate	0	0	0	0
Methionine	0	0	0	0
Lysine	0	0	0	0
Oil	0	0	0	0
Vitamin Premix.	1	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**
Dry matter	88.60	88.80	87.27	89.16
Crude protein	23.98	24.10	24.21	24.13
M.E** (Kcal/kg)	2910.9	2931.8	2904.8	2903.5
Ether extract	4.20	4.26	4.16	4.38
Crude fiber	3.97	4.38	4.54	3.97
Ash	6.01	6.61	7.04	5.73
Methionine	0.52	0.52	0.51	0.53
Lysine	1.08	1.07	1.06	1.10
Linoleic acid	1.40	1.36	1.29	1.49
Calcium	1.35	1.35	1.24	1.35
Phosphorus	0.42	0.42	0.40	

Ration-4: The ration-4 was served as Control (having zero inclusion level of Apple peel for growing Quails); **M. E= Metabolizable energy

Growth Performance

Feed Intake

Isonitrogenous and isocaloric feed was provided to all groups of Japanese quail during morning and evening. Every morning, refusal of feed from all groups was measured, recorded and deducted from feed offered for measuring the consumed feed throughout entire experiment. Feed intake was calculated by the following formula,

$$\text{Feed Intake (gm)} = \frac{\text{Total feed offered- Total feed refused}}{\text{Total Birds}}$$

Live Body Weight (gm)
To measure the total live body weight, three Japanese quails were randomly selected from three replicates per group, weighed (using electric weigh scale) and recorded on 28th day of experiment.

FCR (Feed Conversion Ratio)
Feed conversion ratio was calculated based on total feed consumed by a quail for gaining one kg weight. Thus, the feed conversion ratio actually the feed consumed by the bird for achieving one kg live body weight

$$FCR = \frac{\text{Total feed intake}}{\text{Total body weight}} \times 100$$

Carcass weight
The carcass weight was measured on 28th day of experiment. Carcass weight was calculated by the following formula;

Carcass weight = Total Live Weight - Dressing Weight

Dressing Percentage %
After dressing (de-feathering), the dressing percentage was measured on 28th day of experiment. The dressing percentage was calculated with formula,

$$\text{Dressing (\%)} = \frac{\text{Total dressing weight(kg)}}{\text{Total body weight (kg)}} \times 100$$

Mortality percentage %
The mortality percentage was recorded, and final mortality rate was calculated by using following formula,

$$\text{Mortality (\%)} = \frac{\text{Total birds died}}{\text{Total birds reared}} \times 100$$

Blood Profile
To determine blood profile, three selected bids were slaughtered. The blood profile from each bird per replicate was determined at the completion of trial by obtaining the blood samples. The serum was separated by centrifuging at 3000 rpm for ten minutes and stored at -18 ^{0}C until further analysis. The total protein, total lipids, total cholesterol, glucose, calcium and phosphorus was determined in serum as suggested by Aggoor *et al.* (2000).

STATISTICAL ANALYSIS
The obtained data was statistically analyzed by using analysis of variance (Steel et al., 1997) under completely randomized design, whereas difference among means was compared for significance by applying Duncan's multiple range test (Duncan, 1955).

RESULTS
Feed intake (g)
Results on the effect of apple peel feeding on feed intake of Japanese quail are mentioned in Figure-1. Data indicates that group D took maximum feed intake (268.53 g/b) followed by group C (259.6 g/b) and B (253.22 g/b), respectively. The minimum feed intake was observed in group A (245.4 g/b). Statistical analysis of the data obtained showed that there was significant ($p<0.05$) difference in feed intake among the groups.

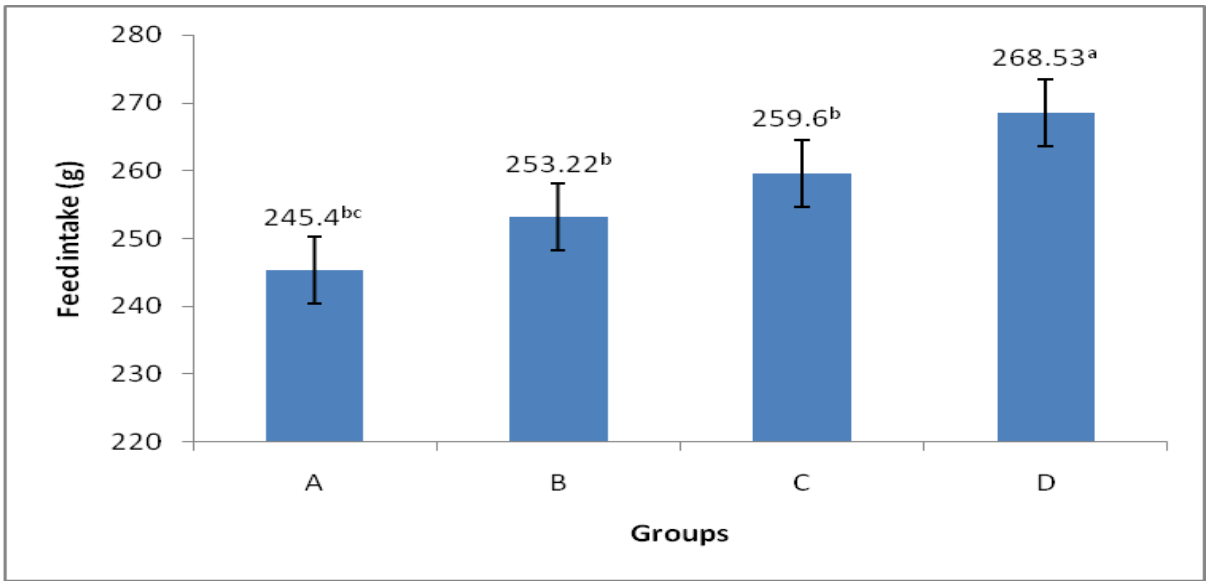


Figure-1: Effect of apple peel feeding on feed intake (g) of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Water intake (ml)

Results on the effect of apple peel feeding on water intake of Japanese quail are mentioned in Figure-2. Data indicates that group D drink maximum water intake (537.06 ml/b) followed by group C (519.2 ml/b) and B (506.44 ml/b), respectively. The minimum water intake was observed in group A (490.8 ml/b). Statistical analysis of the data obtained showed that there was significant ($p<0.05$) difference in water intake among the groups.

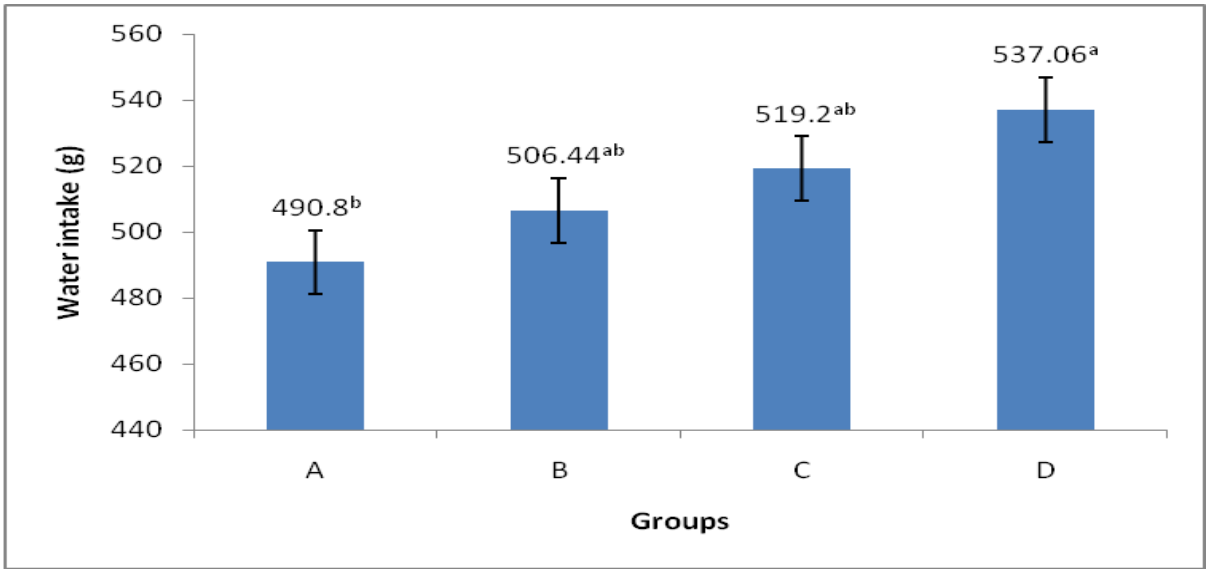


Figure-2: Effect of apple peel feeding on water intake (ml) of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Body weight (g)

Results on the effect of apple peel feeding on body weight of Japanese quail are mentioned in Figure-3. Data indicates that group C received maximum body weight (141.43 g/b) followed by group B (132.43 g/b) and A (124.88 g/b), respectively. The minimum body weight was observed in group D (110.24 g/b). Statistical analysis of the data obtained showed that there was significant ($p<0.05$) difference in body weight among the groups.

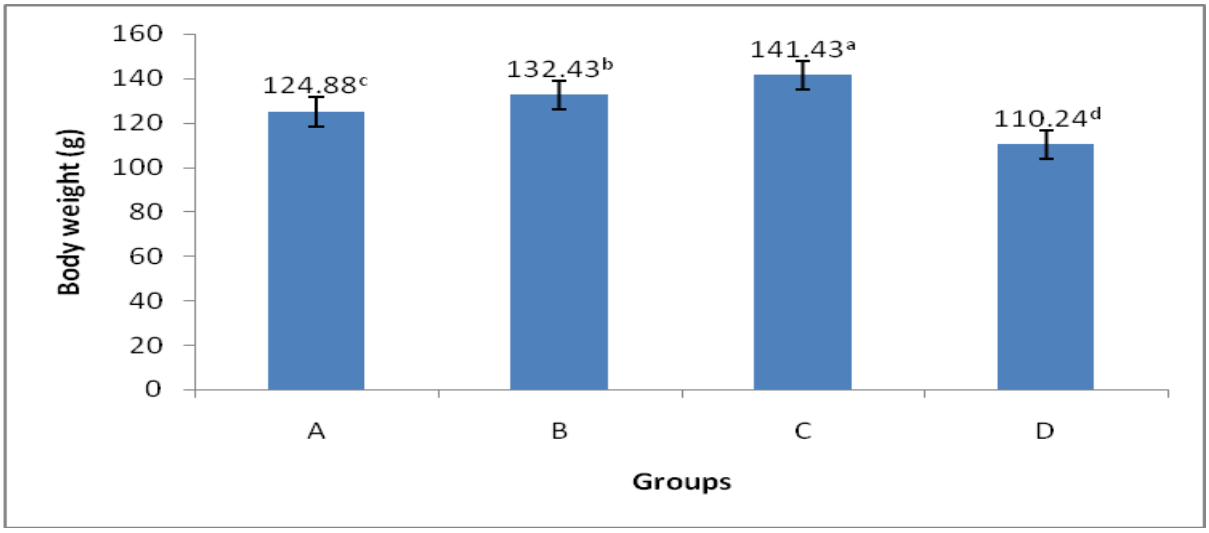


Figure-3: Effect of apple peel feeding on body weight (g) of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

FCR

Results on the effect of apple peel feeding on FCR of Japanese quail are mentioned in Figure-4. Data indicates that group C received minimum FCR (1.84) followed by group B (1.91) and A (1.97), respectively. The maximum FCR was observed in group D (2.44). Statistical analysis of the obtained data showed that there was significant ($p<0.05$) difference in FCR among the groups.

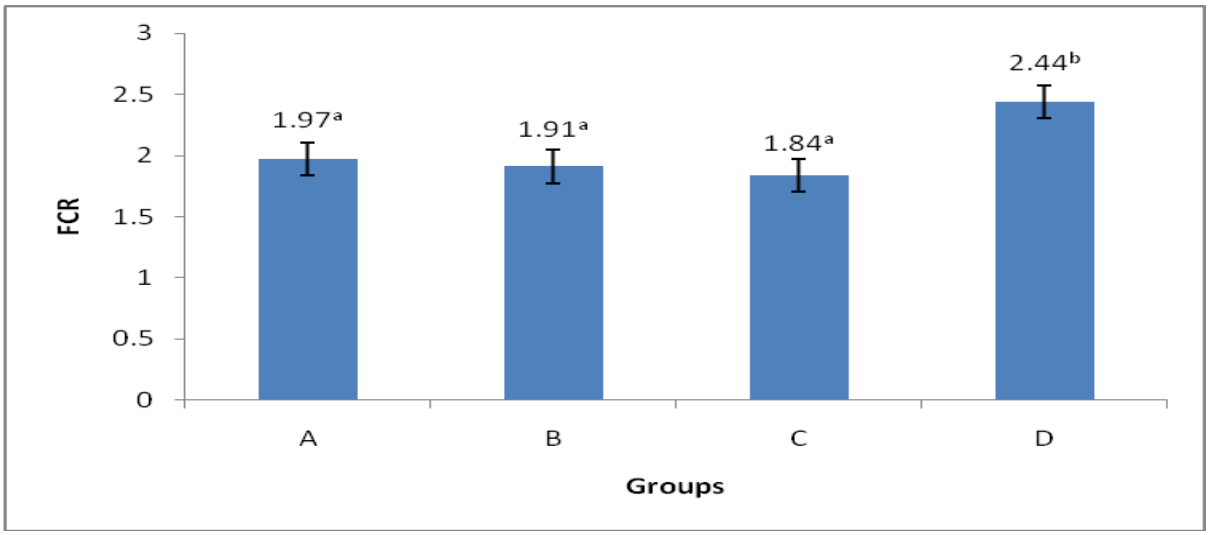


Figure-4: Effect of apple peel feeding on FCR of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Carcass weight (g)

Results on the effect of apple peel feeding on carcass weight of Japanese quail are mentioned in Figure-5. Data indicates that group C received maximum carcass weight (111.43 g/b) followed by group B (102.43 g/b) and A (94.88 g/b), respectively. The minimum carcass weight was observed in group D (80.24 g/b). Statistical analysis of the obtained data showed that there was significant ($p<0.05$) difference in carcass weight among the groups.

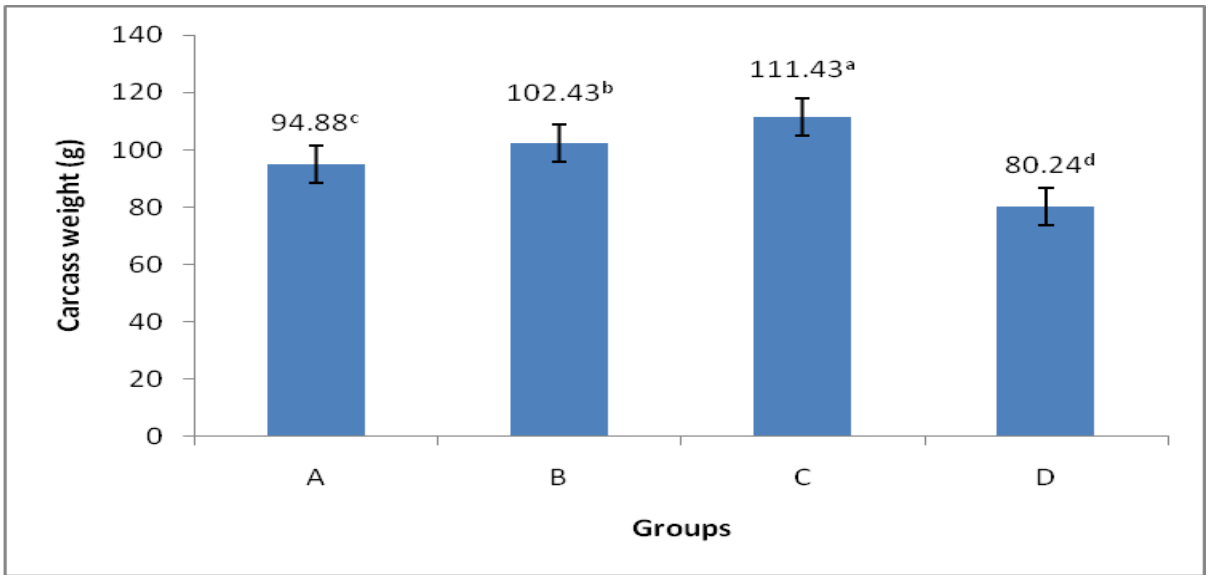


Figure-5: Effect of apple peel feeding on carcass weight (g) of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Dressing (%)

Results on the effect of apple peel feeding on dressing (%) of Japanese quail are mentioned in Figure-6. Data indicates that group C received maximum dressing (78.78%) followed by group B (77.34%) and A (75.97%), respectively. The minimum dressing was observed in group D (72.78%). Statistical analysis of the obtained data showed that there was no significant ($p>0.05$) difference in dressing (%) among the groups.

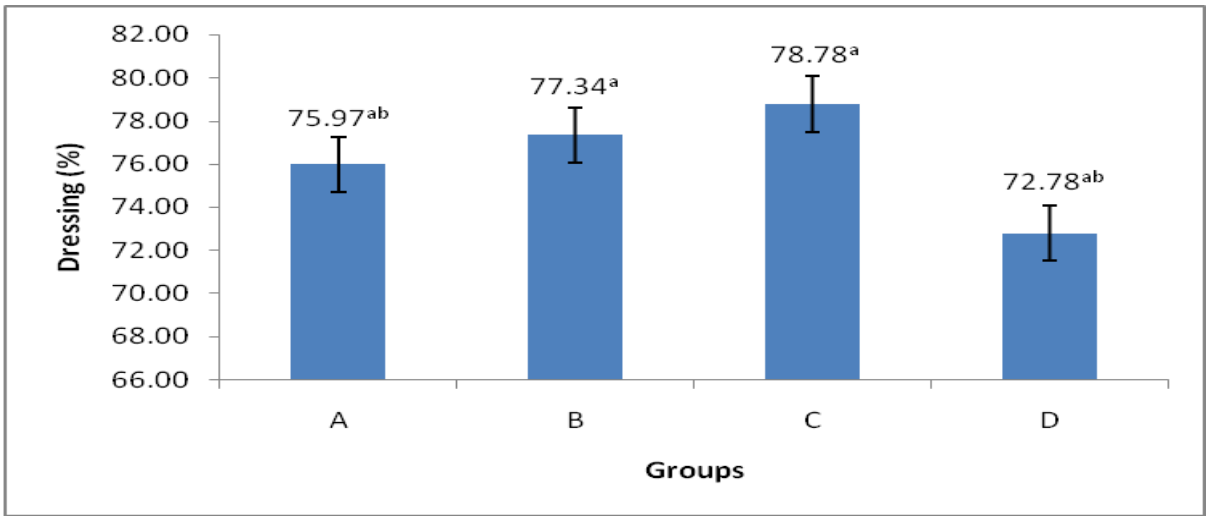


Figure-6: Effect of apple peel feeding on dressing (%) of Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Total protein (mg/L)

Results on the effect of apple peel feeding on total protein concentration in blood of Japanese quail are mentioned in Figure-7. Data indicates that maximum total protein concentration was determined in group C (52.86 mg/L) followed by group B (51.32 mg/L) and A (47.55 mg/L), respectively. The minimum total protein concentration was determined in group D (43.82 mg/L). Statistical analysis of the obtained data showed that there was significant ($p<0.05$) difference in total protein level among the groups.

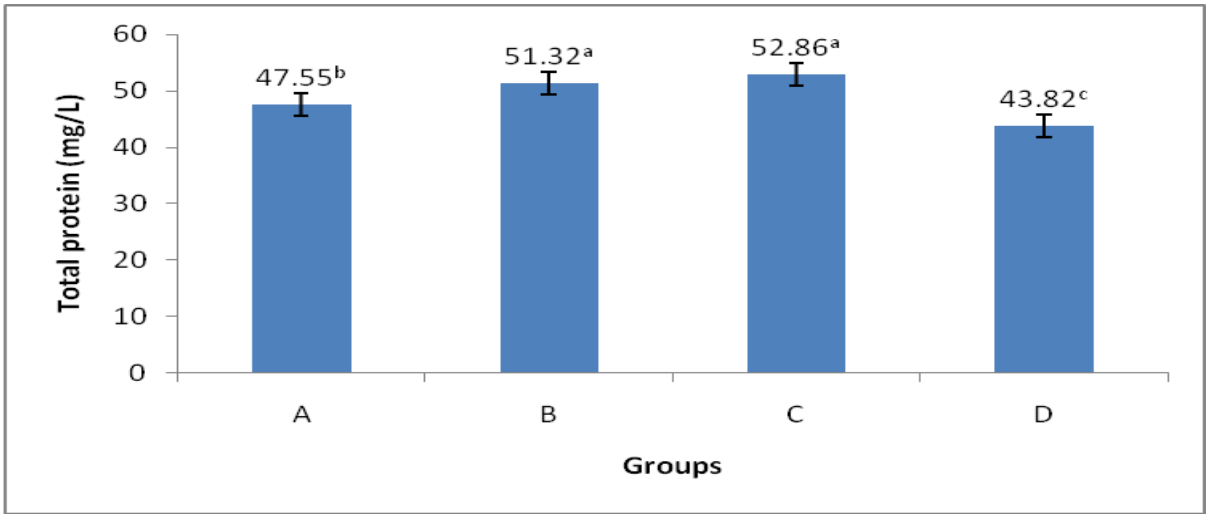


Figure-7: Effect of apple peel feeding on total protein level in Japanese quail blood.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Total lipids (mg/L)

Results on the effect of apple peel feeding on total lipids concentration in blood of Japanese quail are mentioned in Figure-8. Data indicates that maximum total lipids concentration was determined in group C (457.21 mg/L) followed by group B (443.81 mg/L) and A (436.55 mg/L), respectively. The minimum total lipids concentration was determined in group D (428.51 mg/L). Statistical analysis of the data obtained showed that there was no significant ($p>0.05$) difference in total lipids level among the groups.

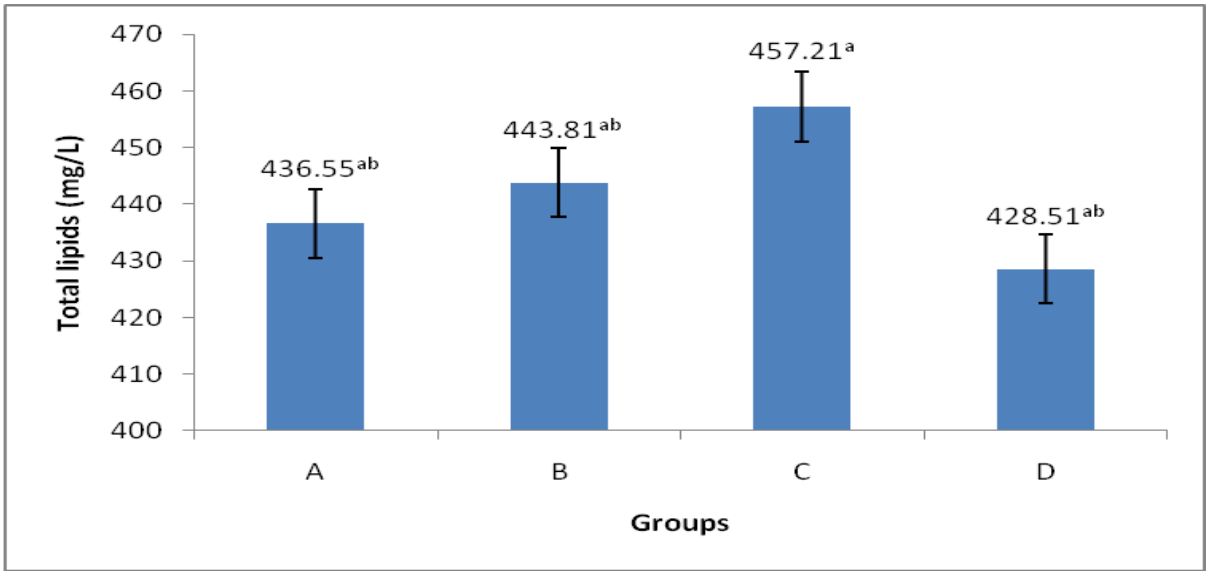


Figure-8: Effect of apple peel feeding on total lipids level in Japanese quail blood.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Total cholesterol (mmol/L)

Results on the effect of apple peel feeding on total cholesterol concentration in blood of Japanese quail are mentioned in Figure-9. Data indicates that maximum total cholesterol concentration was determined in group D (4.32 mmol/L) followed by group A (3.32 mmol/L) and B (3.29 mmol/L), respectively. The minimum total cholesterol concentration was determined in group C (3.15 mmol/L). Statistical analysis of the obtained data showed that there was significant ($p<0.05$) difference in total cholesterol level among the groups.

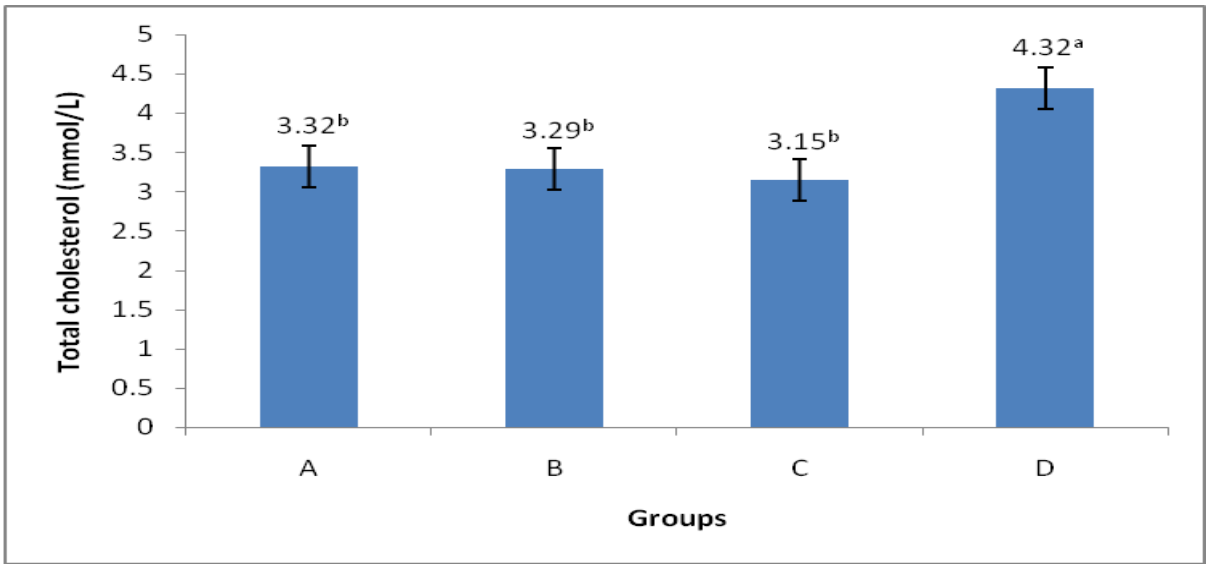


Figure-9: Effect of apple peel feeding on total cholesterol level in Japanese quail blood.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Blood glucose (mmol/L)

Results on the effect of apple peel feeding on blood glucose concentration in Japanese quail are mentioned in Figure-10. Data indicates that maximum blood glucose concentration was determined in group D (3.86 mmol/L) followed by group B (3.27 mmol/L) and A (2.24 mmol/L), respectively. The minimum blood glucose concentration was determined in group D (1.44 mmol/L). Statistical analysis of the data obtained showed that there was significant ($p<0.05$) difference in blood glucose level among the groups.

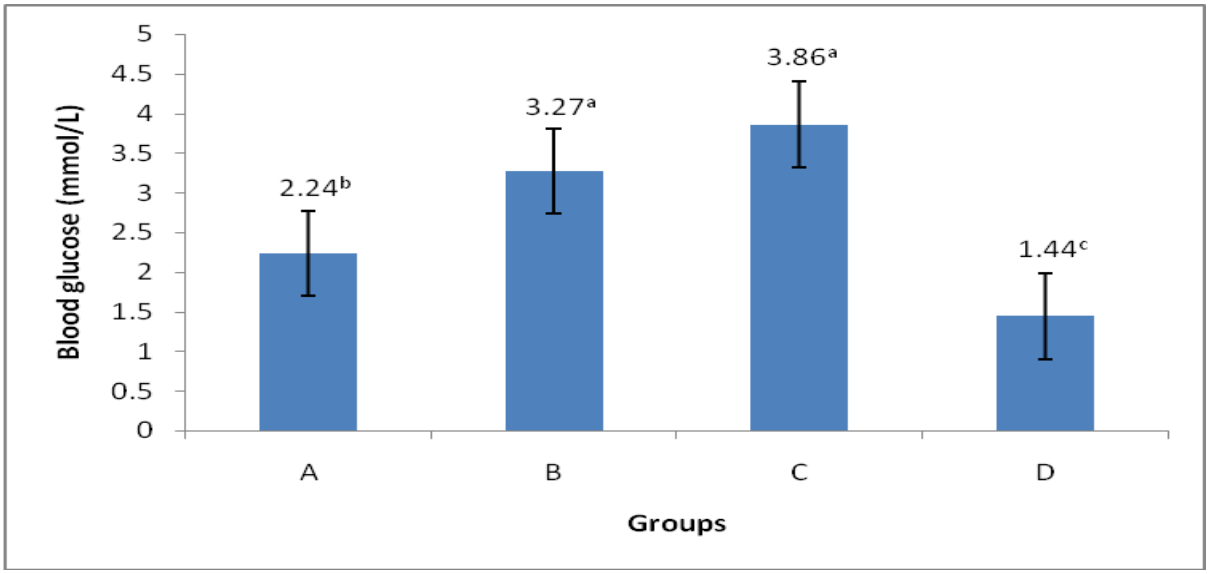


Figure-10: Effect of apple peel feeding on blood glucose level in Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Blood calcium (mmol/L)

Results on the effect of apple peel feeding on blood calcium concentration in Japanese quail are mentioned in Figure-11. Data indicates that maximum blood calcium concentration was determined in group D (2.92 mmol/L) followed by group B (2.61 mmol/L) and A (2.43 mmol/L), respectively. The minimum blood calcium concentration was determined in group D (2.35 mmol/L). Statistical analysis of the obtained data showed that there was no significant ($p>0.05$) difference in blood calcium level among the groups.

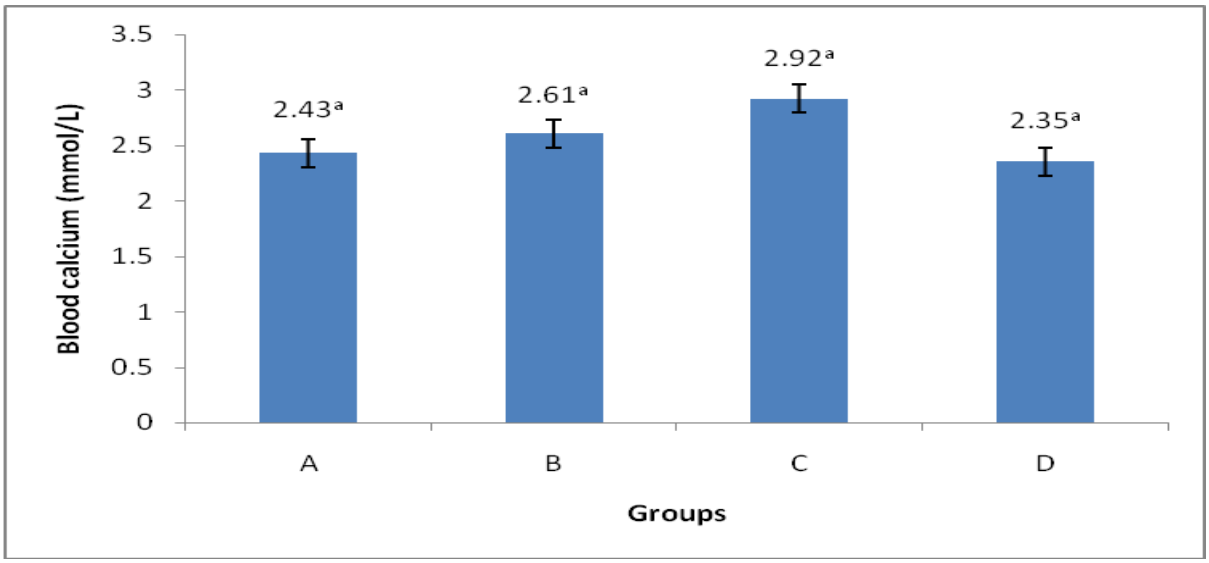


Figure-11: Effect of apple peel feeding on blood calcium level in Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

Blood phosphate (mmol/L)

Results on the effect of apple peel feeding on blood phosphate concentration in Japanese quail are mentioned in Figure-12. Data indicates that maximum blood phosphate concentration was determined in group D (5.31 mmol/L) followed by group B (5.23 mmol/L) and A (5.16 mmol/L), respectively. The minimum blood phosphate concentration was determined in group D (4.88 mmol/L). Statistical analysis of the obtained data showed that there was significant ($p<0.05$) difference in blood phosphate level among the groups.

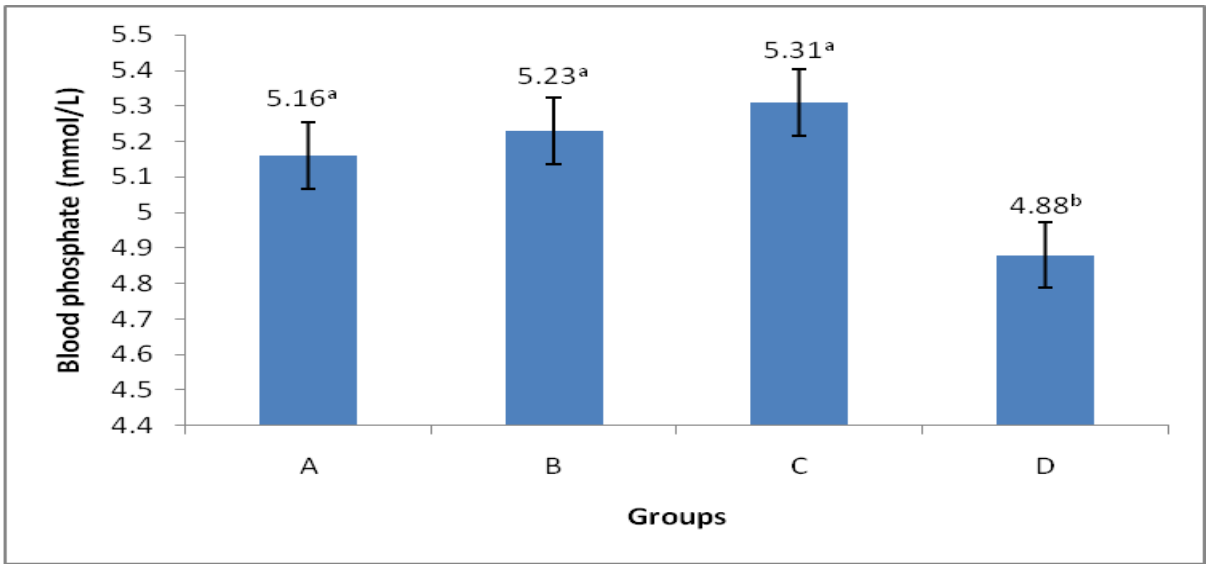


Figure-12: Effect of apple peel feeding on blood phosphate level in Japanese quail.

Group A: 3% apple peel; Group B: 6% apple peel; Group C: 9% apple peel; Group D: 0% apple peel (control); superscripts (a,b,c) in the column indicate significant ($p<0.05$) difference between the groups.

DISCUSSIONS

In our study weight gain of quail significantly higher in broiler supplemented with apple peel. The mango, apple, pineapple, citrus, banana and tomato are the major fruits used for processing in most of the Asian countries including Pakistan, and their waste can be included in livestock diets either as dry product or as silage (El Boushy and van der Poel, 2013; Unar et al., 2025). However, the nutritional value of these fruit wastes is principally important so that balanced diets can be formulated for poultry, especially for chicken. The present studies were carried out to determine the effect of different levels of apple peels on the growth of quails. The quail fed ration with apple peel resulted in high live body weight and FCR. The increase in live weight of quail fed ration with apple peel is possibly due to higher protein content. By feeding apple peel from 6-9 % will be useful and without any adverse effects on quail body weight. But it is probably more advantageous to feed the high rates of apple peels in experimental diets in quail growing ration rather than in starter ration. Because when quail become mature their gastrointestinal tract fully developed and works more efficiently.

Furthermore, El Boushy and van der Poel (2013) reported that citrus fruits waste enhanced the FCR when compared with traditional poultry feed. Chicks receiving apple peel ration consumed less feed compared to broilers taking banana peel ration. It might be more fibre content in of apple peel and may be chicks do not like the smell of feed supplemented. Moghazy and Boushay (1982) also reported that chick's growth was less who taken high fiber. To reduced feed intake and effect of peel on abdominal fat (Oluremi et al., 2007). The more fiber intake through quail probably stimulates the bowl moments result in depression in the weight gain. By supplementing apple peel in the ration although they have less effect on growth performance but possibly improve nutritive value and flavor of the meat. The indices of feed conversion publicized that apple peels can be supplemented to quail diets up to 6-9 % safely devoid of side effect on feed conversion rates. Apple peels increased the live body weight and growth performance of quail, which coincide with previously reports on fruit by-products (Rabayaa et al., 2001; Zafar et al., 2005; Keithly and Taggart, 2006; Oluremi et al., 2006; Oluremi et al., 2007; Soomro et al., 2013).

CONCLUSION

It was concluded from the present study that Japanese quails feeding with apple peel 9% obtained highest body weight gain, carcass weight and shows maximum blood profile values.

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Author Contributions
SA is a manuscript researcher. NM, KM and MI supervised study conducted. IU and NUM guided to conduct research in laboratory. NM helped in data collection and performed statistical analysis and contributed to interpretation of results. JK and BA helped in formal analysis. FH and SN helped in manuscript writing review and editing.

Conflict of Interest
The authors declared that there is no conflict of interest regarding the publication of this research.

Data Availability
The original data of study is available.

Ethical Statement
The current study, which was authorized by the Institutional Review Board (IRB)/Bioethics Committee under license number IRB-AN-102, was conducted in the main campus of Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Uthal, Balochistan, Pakistan.

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