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Research Article

Feeding Effect of Organic and Inorganic Zinc with Vitamin E on Growth Performance and Carcass Quality of Japanese Quail

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Abstract: The research facility of Avian Research & Training (ART) Center (Poultry Production), UVAS, Lahore was selected to investigate the effect of feeding organic and inorganic zinc in addition to vit-E on the growth performance of Japanese quail. for a period of 6 months. The diet formulated by the inclusion of Zn*O* + Zn*I* (mg)+VE(IU) as 0+0+0 (A), 25+0+0 (B), 0+15+0 (C), 0+0+12 (D), 25+15+0 (E), 25+0+12 (F), 0+15+12 (G) and 25+15+12 (H), respectively. The effect of zinc and vit-E on growth and slaughter traits of Japanese quail was significant (P<0.05) and it was perceived that in 6 weeks the broiler quails in groups H and F took higher feed (745.44 and 734.70 g/bird), with simultaneous effect on LBW of males (175.35 and 174.50 g), females (198.35 and 197.38 g), average (186.85 and 185.94 g), intestine filled (6.81 and 6.66 g) and empty weights (5.51 and 4.88 g), intestine length (44.87 and 44.75 g), cecal length (16.37 and 16.12 cm), the weight of carcass + giblets (142.01 and 141.48 g), carcass (130.88 and 130.25 g), heart (2.18 and 2.16 g), liver (5.02 and 5.06 g), gizzard (5.62 and 5.21 g), respectively. The dietary Zn + vit-E inclusion significantly (P<0.05) increased the relative length of gut segments, villi height, villus thickness, the villi height to crypt depth proportion in jejunum and ileum and the number of goblet cells in various parts of the intestine of quails. The meat production was significantly higher in female quails than the meat of male quails. This suggested that the organic Zn proved to be better than the inorganic Zn source in addition to vit-E to achieve physiology-related traits in quails.

Keywords: Japanese quail, organic/inorganic zinc, vit-E, growth performance

1. INTRODUCTION

Rural poultry farming has the potential to bridge the gap between animal protein supply and requirement of fast increasing human population. Japanese quail are not only fancy birds, but they produce high-quality meat that is most delicious in the avian species; it can produce up to four generations in a year, and rapid production of delicious meat-producing birds makes it the most effective and suitable poultry bird.

Japanese quail (*Coturnix coturnix japonica*) is a small game bird commercially raised for meat production [1]. The female quails' complete maximum egg production at the age of 50 days, whereas the males need around 6 weeks to reach sexual maturity. Quails are the most productive and appropriate poultry birds since they may generate up to four generations each year of excellent meat-producing birds. The adult female quail weighs between 120 and 160 g in live weight, and the mature male weighs between 110 and 140 g. The typical egg is 10 g. Quail laid eggs in the twilight, and they may take 17 to 18 days to hatch [2]. The Japanese quail is a member of the Phasianidae family and is a well-known migrant bird, moving often between Asia and Europe [3].

Quail has been gaining popularity as a meat bird due to its nutritional value, taste, and

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texture. Here are some citations that highlight the importance of quail as a meat bird. Quail meat is an excellent source of protein and contains essential amino acids, vitamins, and minerals. It has low-fat content, making it a healthy choice for meat consumption [4]. Quail meat has a high content of polyunsaturated fatty acids (PUFAs) and a low level of saturated fatty acids (SFAs), making it a healthier meat option compared to other poultry. Quail meat is also known for its tender and juicy texture, making it a popular choice among chefs and food enthusiasts [5]. Quail meat had a higher water-holding capacity compared to chicken meat, contributing to its unique texture. Quail is also a sustainable meat option, as it requires less space, feed, and time to raise compared to other livestock animals [6]. Quail farming has a low environmental impact and can provide a reliable source of protein for households in developing countries. Finally, quail meat is used in traditional medicine for its potential health benefits [7].

The poultry industry in Pakistan has overlooked quail farming, even though it has enormous potential, owing to a lack of study on the nutritional requirements of quails and general management in the local environment. This is true even though it can dramatically boost the economy of the country [8]. In addition, the use of antioxidants has risen due to the incorporation of polyunsaturated fat-rich components into the formulation of animal feeds which presents an additional advantage. Feeds that are rich in polyunsaturated fatty acids are extremely susceptible to lipid peroxidation [9]. It has been established that antioxidants perform a broad variety of biological roles, including several that are relevant to both animals and humans [10]. Oxidative stress and a subsequent decline in performance by a variety of factors, including those related to their nutrition, pathology, their physiology, and their environment [11]. As a consequence of this, it has been discovered that poultry birds can experience a reduction in the detrimental effects of oxidative stress when they consume antioxidants, and their growth is improved. In addition to the vitamins and minerals that may be found in food, the biochemical processes in the body require a diverse array of other nutrients. It has been discovered that the addition of antioxidants to animal-based foods improves oxidative stability, tenderness, storage properties, and colour [12].

Antioxidants like zinc and vitamin E are given to animal feed to enhance performance, promote immunity, improve the quality of meat and eggs, and increase the amount of vitamin E present in animal-derived foods so that humans may consume more of it [13]. Supplementing with zinc and vitamin E has antioxidant effects that may lessen certain physiological symptoms and boost thermotolerance [14]. Oxidative stress may occur in chicken production for a number of reasons, most often high temperatures, health issues, and poor feed quality [15]. Increasing the antioxidant capacity of the body can be ameliorated by consuming foods that include antioxidants, such as vitamin E, as well as antioxidant enzyme precursors, such as selenium, which is an essential component of Glutathione peroxidase [16-17]. The administration of Zn results in a significant rise in the blood concentrations of vitamins C and E, as well as zinc, in chickens [18]. Because it influences fat metabolism, zinc has a good antioxidant effect when combined with vitamin E to combat the negative effects of heat stress [19], combining vitamin E, a well-known antioxidant, with zinc, an antioxidant agent, may boost the activity of antioxidant enzymes. Zinc and vitamin E work together to promote the overall health and performance of birds by strengthening their immune systems and nutrition [20]. The spleen and bursa weight ratios of quails fed on zinc in either organic or inorganic form at a dose of 50 mg/kg meal were unaffected by the zinc supplementation [21]. Considering the above hypothesis, the study was conducted to determine the effects of Zn and vitamin E supplementation alone or in combination with the diet on the growth and production performance of Japanese quails.

2. MATERIALS AND METHODS

The experiment was conducted at the Avian Research & Training (ART) Center, Department of Poultry Production, University of Veterinary and Animal Sciences (UVAS), Lahore for a period of 6 months. Lahore has a hot semi-arid climate (Koppen climate classification BSh), with long, rainy, warm summers, and dry winters, as well as dust storms and a monsoon. During the months of May, June, and July, temperatures rise to between 40 and 48 °C. The monsoon season lasts from late June to August.

A total of 960-day old quail chicks were procured from the hatchery unit at the Avian Research and Training (ART) Center, University of Veterinary and Animal Sciences (UVAS) Lahore. Using CRD chicks were distributed in eight groups (4 replicates/ group) (Table 1). The quail chicks were reared in an open-sided house in cages and had free access to feed and water. Overall growth performance in terms of weight gain, FCR, Mortality, etc was investigated. At the age of 6 weeks, 02 (01 male and 01 female) birds from each replicate, were randomly taken, weighed, and slaughtered. The birds were reweighed and eviscerated. Carcass weight and weights of gizzard, liver, heart, alimentary canal, and abdominal fat were recorded.

The birds were given a starter basal diet containing 22 % crude protein (CP), and 2800 kcal/ kg metabolizable energy (ME). Seven experimental diets (B, C, D, E, F, G, and H) were formulated. The ration was made by Hi-Tech Feed Industries (Pvt.), Lahore, Pakistan, according to NRC standards (1994) (Table 2). The experiment was conducted in three phases i.e., growth, production, and hatching phase.

Day-old quail chicks were weighed individually when they arrived, and subsequent body weight measurements taken at weekly intervals for each experimental duplicate were subsequently recorded. After the sixth week, final body weight was also recorded. A sophisticated computerized digital balance was used to properly weigh the test birds. As a result, the measured weight was recorded for each bird separately by reading the scale. The quantity of feed supplied to each duplicate each day was weighed, and the residual was then quantified the next day. Each bird's feed consumption was recorded in order to determine weekly feed intake. The formula utilized was as follows: Feed intake is calculated as follows: number of birds = feed provided - feed residue during a certain time.

Two birds from each replicate—a male and a female—were chosen at random at the end of the experiment and kept off food for 5 to 6 hours before being slaughtered to maintain their intestines and crops clear of the undigested meal (feed withdrawal period). The birds were killed using a halal technique to guarantee full bleeding. Before killing, each bird was weighed individually on an advanced computerized digital balance, and all the organs were weighed as well.

Statistical Analysis

Data collected was analyzed through the one-way analysis of variance (ANOVA) technique under a Completely Randomized Design (CRD) as suggested by Hamid *et al* [22]. Means were compared through Duncan's Multiple Range (DMR) test using statistical analysis software (JMP 7.0).

3. RESULTS

3.1 Feed Intake (g/bird)

Table 3 shows that the feed intake of quails (1-6 weeks) varied significantly (P<0.05) due to the inclusion of Zn of diverse sources and vitamin E. The quails in groups H and F took more feed

Table 1. Treatment plan from day old to 6th weeks

Groups	Diets		
	Zinc (Organic) (mg/kg)	**Zinc (Inorganic) (mg/kg)**	**Vit. E (IU/kg)**
A (Control)	0	0	0
B	25	0	0
C	0	15	0
D	0	0	12
E	25	15	0
F	25	0	12
G	0	15	12
H	25	15	12

8 treatments * 4 Replicates * 30 Birds in each replicate = 960 birds

***1U =** 1U/kg = 0.67mg dl-ά-tocopherol acetate

Table 2. Feed formulation used in this experiment.

	Chemical Composition (%)							
Ingredient	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Corn (CP = 8 %)	54.985	54.96	54.97	54.972	54.945	54.947	54.957	54.932
Soybean meal (CP=42.78 %)	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5
DCP (P=18 %, Ca=21 %)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Oyster shell (Ca = 38 %)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
NaCl	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Vitamin supplement	0.012	0.012	0.012	0.025	0.012	0.025	0.025	0.025
Mineral supplement	0	0.025	0.015	0	0.04	0.025	0.015	0.04
DL-Methionine	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
L-Threonine	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Washed sand	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Chemical composition								
ME (Kcal/kg)	2773	2773	2773	2773	2773	2773	2773	2773
Crude protein	22.68	22.68	22.68	22.68	22.68	22.68	22.68	22.68
Calcium	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Available phosphorus	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Sodium	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Lysine	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
Methionine	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Methionine + Cystine	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Threonine	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Arginine	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54
Zinc (mg/kg)	0	0.0025	0.0015	0	0.004	0.0025	0.0015	0.004
Vitamin E	0.0012	0.0012	0.0012	0.0025	0.0012	0.0025	0.0025	0.0025

Table 3. Feed intake of Japanese quail (g/bird)

Groups	1st week	2nd week	3rd week	4th week	5th week	6th week	Average
A	22.45	66.17	99.08	152.13	177.1	173.04	689.97d
B	22.88	75.84	105.41	143.45	176.23	171.04	694.85cd
C	18.92	64.22	111.05	155.87	174.8	169.67	694.53cd
D	22.32	72.13	103.22	150.44	173.83	171.84	693.78bcd
E	24.55	72.29	117.83	158.47	175.47	171.75	720.36abc
F	23.7	76.47	115.53	157.23	186.32	175.45	734.7b
G	23.86	81.8	103.07	153.27	186.68	175.46	724.14ab
H	21.54	77.43	113.85	158.77	194.97	178.88	745.44a
	22.40f	72.45e	107.51d	153.95c	182.02b	174.77a	--

	Treatments (T)	Weeks (W)	T × W
S.E.±	8. 802	6.953	13.814
LSD 0.05	17.285	13.635	66.836
P-Value	0.0005	0.0000	0.0449

during six weeks' period (745.44 g and 734.7 g/bird), respectively; followed by the average feed consumption of 724.14 and 720.36 g/bird in groups G and group E, respectively. The average feed intake was relatively lower (700.78 g, 694.53, and 694.85 g/bird) in groups D, C and B, respectively; while the lowest average feed intake (689.97 g/bird) was observed in control group A. Statistically, the birds in groups H and F showed similar behavior regarding feed intake; while in lower feed intake groups C and B were similar (P>0.05). The average quail's feed consumption is influenced by the zinc source and the addition of vitamin E. However, the absence of zinc as picolinate in feed caused a significant decrease in average feed intake in the presence of $ZnSO_4$. Similarly, the quails' feed choice was significantly affected due to the presence or absence of vitamin E. This indicates that the inclusion of organic zinc (picolinate) was preferred by quails over $ZnSO_4$; while birds were pleased to take more feed when Vitamin E was added.

3.2 Live Body Weight of Slaughtered Birds

After 6 weeks, the live body weight (LBW) of quails were taken in different treatment groups comprised of a certain concentration of organic and inorganic zinc in addition to vitamin E. Table 4 exhibited that the LBW of birds designated in different treatment groups varied significantly (P<0.05). The male quails in group H possessed the highest LBW (175.35 g), followed by the quails of groups F, G, and E possessing LBW of 174.50, 173.45, and 172.0 g/bird, respectively. The LBW showed a decreasing trend (171.48, 171.23, and 170.13 g/bird) in groups D, B, and C, respectively. Whereas, the male quail LBW was the least (170.13 g/bird) in control group A. Statistically, the birds in groups H and F (P>0.05); groups G and E (P>0.05), and birds in groups B, C, and D showed similarity (P>0.05) for LBW.

The female LBW was also measured (Table 4) which exhibited female quails in group H possessed highest LBW (198.35 g), followed by the quails of group F, G, and E possessing LBW of 197.38, 196.5, and 196.45 g/bird, respectively. The LBW showed a decreasing trend (194.13,194.00 and 193.48 g/bird) in groups B, D, and C, respectively. Whereas the female quail LBW was least (192.23 g/bird) in control group A. Statistically, the birds in groups H and F (P>0.05); groups G and E (P>0.05), and birds in groups B, C, and D showed similarity (P>0.05) for LBW.

The feeding quails with a diet with zinc and vitamin E showed a positive impact on their LBW as indicated from the comparative analysis of treatments with control. The comparison of organic and inorganic zinc suggested that organic zinc

Table 4. Live body weight of slaughtered birds' male/female (g/bird)

Group	Sex		Average
	Male	Female	
A	169.38^{d}	192.23^{e}	180.81^{g}
B	171.23^{c}	194.13^{d}	182.68^{e}
C	170.13^{c}	193.48^{d}	181.81^{f}
D	171.48^{c}	194.00^{d}	182.74^{e}
E	172.00^{b}	196.45^{c}	184.23^{d}
F	174.50^{a}	197.38^{b}	185.94^{b}
G	173.45^{b}	196.5^{c}	184.98^{c}
H	175.35^{a}	198.35^{a}	186.85^{a}
172.19^{b}	**195.32^{a}**	**--**	

	Treatments (T)	Sex(S)	T × S
S.E.±	0.6407	0.9203	0.3403
LSD 0.05	1.4847	2.7424	0.6855
P-Value	0.0000	0000	1.0000

(picolinate) proved to have a better positive impact on male LBW as compared to those given inorganic Zn ($ZnSO_4$). Moreover, the addition of Vitamin E also showed an encouraging impact on male LBW even better than $ZnSO_4$. It can be concluded that for achieving healthy male quails, the organic zinc (picolinate) in addition to a certain level of Vitamin-E would be optimum supplementation, rather to add both organic (picolinate) and inorganic zinc ($ZnSO_4$).

3.3 Feed Conversion Ratio

The FCR of quails after 6 weeks were calculated to see the effect of dietary Zn + Vit-E and the results are given in Figure 1. The FCR was significantly influenced by the dietary Zn + Vit-E treatments ($P<0.05$). The birds kept in group F showed the highest FCR (3.59), followed by the birds in groups D, B, and C with average FCRs of 3.75, 3.75, and 3.76, respectively. The FCR in quail groups E, G, and H was not encouraging due to increased feed intake but not a simultaneous increase in weight gain. The quails in group F utilized feed more efficiently, which is clear from the nutrient digestibility results, and gain more weight as compared to the rest of the treatments.

3.4 Mortality (%)

The quail flocks were also monitored for mortality rate during 6 weeks of the experiment and the data are shown in table 5. It was noted that there was negligible effect of treatments based on organic and inorganic zinc with vitamin E in various combinations on the mortality rate ($P>0.05$). The overall mortality was higher (2.75 %) in control group A, followed by groups B and C, D with an

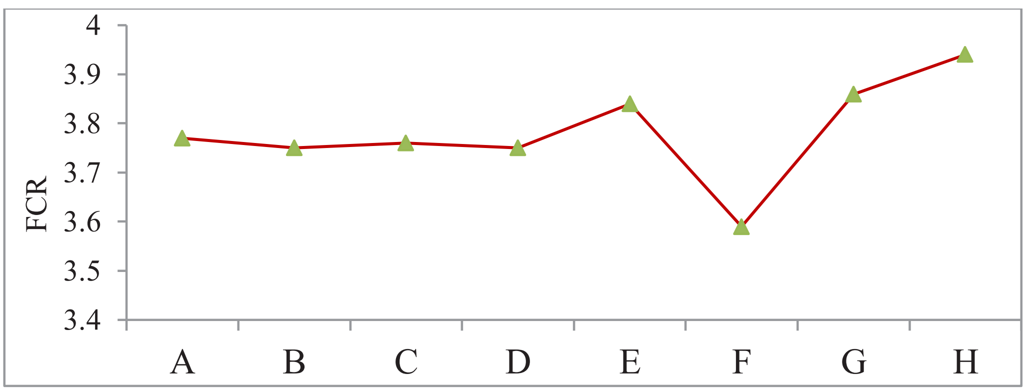

Fig. 1. Feed conversion ratio (FCR) of Japanese quail

Table 5. Mortality rate of Japanese quail

	Total
A	2.75[a]
B	2.50[ab]
C	2.50[ab]
D	2.25[b]
E	1.50[ab]
F	1.25[b]
G	1.50[ab]
H	1.25[b]

	Treatments (T)	Sex (S)	T × S
S.E.±	0.5121	0.2561	0.7242
LSD 0.05	1.0315	0.5157	1.4587
P-Value	0.7464	0.3935	0.0821

average mortality of 2.50, 2.50, and 2.25 percent, respectively. However, lower mortality rate (1.50 and 1.50 %) was recorded in groups E and G, respectively; while the equally lowest mortality rate of 1.25 % was seen in quails of groups H and F, respectively.

3.5 Slaughter Characteristics

3.5.1. Carcass + Giblets Weight of Quails (g/bird)

The carcass + giblets weight of slaughtered birds at 6 weeks of age were recorded to assess the treatment effect and the results are shown in Figure 2. The data demonstrated that the carcass + giblets weight of slaughtered birds was significantly affected (P>0.05) by organic and inorganic zinc in addition to vitamin E combinations. The carcass + giblets weight of male, and female birds and average in group H was higher (139.34, 144.68, avg: 142.01 g/bird) than the birds in groups F, G, and E with male, female carcass + giblets weights and the average of 138.31, 144.65, avg: 141.48 g/bird; 130.37, 143.23, avg: 136.80 g/bird, 131.76, 138.67, avg: 135.22 g/bird, respectively. Relatively lower carcass + giblets weight in male, female birds and average was recorded in group D; B and C, i.e., 134.73, 137.49, avg: 136.11 g/bird; 130.70, 134.64, avg: 132.67 g/bird; 128.87, 128.72, avg: 128.80 g/bird, respectively. However, male, female, and average carcass + giblets weight was least (126.95, 129.88, avg: 128.42 g/bird), respectively in control group A. The DMRT indicated that quails in groups H and F showed similar carcass + giblets weight suggesting that the inclusion of inorganic zinc in the presence of organic zinc was unnecessary. However, organic Zinc + Vit- E combination was more effective as compared to the inorganic Zinc + Vit-E combination. Moreover, the inclusion of Vit-E was also more effective than the inorganic zinc.

3.5.2. Carcass Weight of Quails (g/bird)

The results (Fig 3) illustrated that the effect of organic and inorganic zinc with vitamin E combinations on carcass weight was significant (P<0.05). The carcass weight of male, female birds and average in group H was maximum (127.75, 134, avg: 130.88 g/bird), followed by the birds in groups F, G, and E with male, female carcass + giblets weights and average of 130, 130.5, avg: 130.25 g/bird; 118.50, 131.78, avg: 125.14 g/bird, 126.25, 122.0, avg: 124.13 g/bird, respectively. The carcass weight was lesser for male, female birds and average in groups D; B and C, i.e., 114.50, 133.5, avg: 124 g/bird; 122.25, 123, avg: 122.63 g/bird; 117.25, 118.25, avg: 117.75 g/bird, respectively. The least male, female, and average carcass weight (118.25, 115.75, avg: 117 g/bird), respectively was recorded in control group A. The statistical analysis suggested that the carcass weight in birds of groups H and F were almost equal which clearly advocates that the addition of zinc in organic form (picolinate) with vitamin E combination was more effective as compared to combining both organic (picolinate) and inorganic zinc ($ZnSO_4$) with vitamin E. However, the inclusion of vitamin E

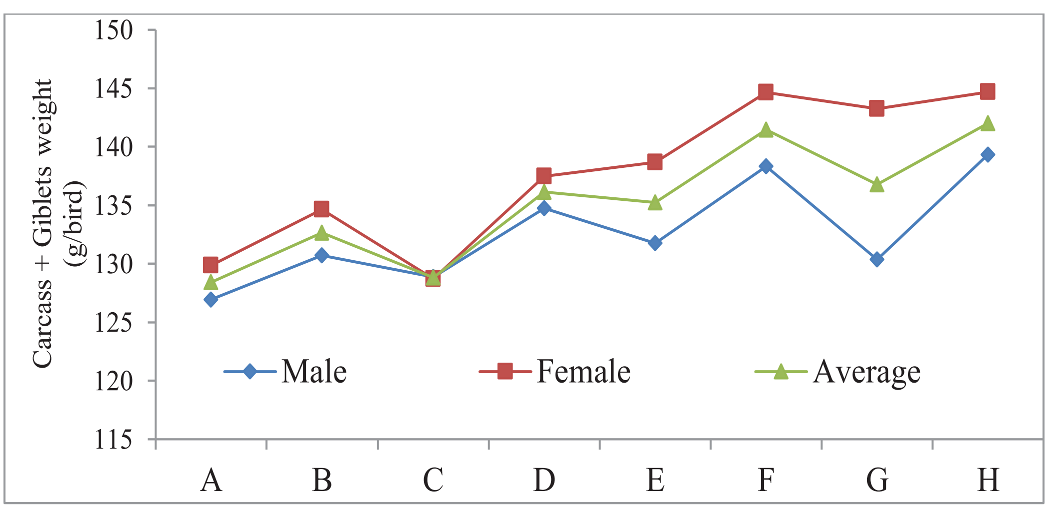

Fig. 2. Carcass + giblets weight of Japanese quail

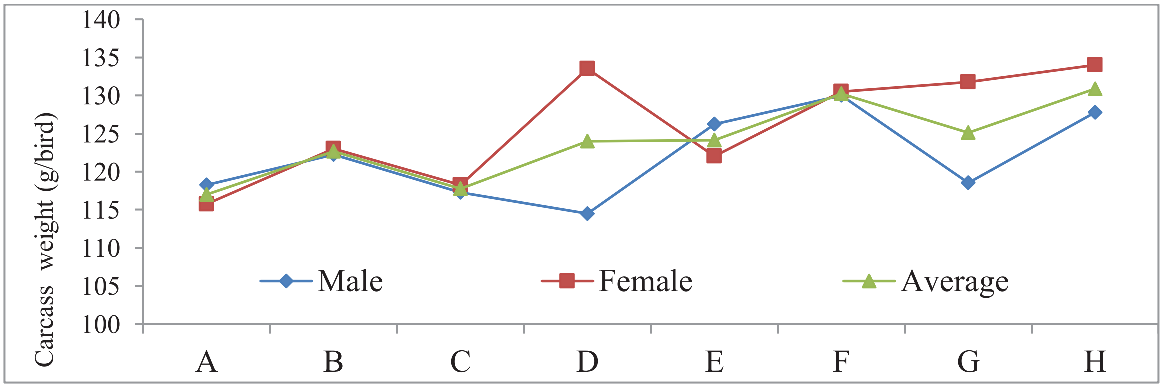

Fig. 3. Carcass weight of Japanese quail

resulted in better carcass weight when compared to the inclusion of inorganic zinc so far, the carcass weight is concerned.

3.5.3. Heart Weight of Quails (g/bird)

The results (Table 6) exhibit that the effect of organic and inorganic zinc with vitamin E combinations on heart weight was significant ($P<0.05$). The heart weight of male, female quails and their average in group H was highest (2.09, 2.26, avg: 2.18 g/bird), followed by the quails of groups F, G, and E with male, female heart weight and an average of 1.94, 2.38, avg: 2.16 g/bird; 1.81, 2.3, avg: 2.06 g/bird, 1.97, 2.06, avg: 2.02 g/bird, respectively. The heart weight was markedly lower for male, female birds and average in groups D; B, and C, i.e., 1.82, 1.87, avg: 1.85 g/bird; 1.78, 1.86, avg: 1.82 g/bird; 1.52, 1.94, avg: 1.73 g/bird, respectively. The lowest male, female, and average heart weight (1.49, 1.9, avg: 1.7 g/bird), respectively was recorded in control group A.

3.5.4. Liver Weight of Quails (g/bird)

The results (Table 7) revealed that different combinations of organic and inorganic zinc with vitamin E had an insignificant effect ($P>0.05$) on liver weight. The liver weight of male, female birds and their average in group H was maximum (4.37, 5.75, avg: 5.06 g/bird), followed by the quails of groups F, G, and E with male, female liver weight and average of 4.47, 5.56, avg: 5.02 g/bird; 4.41, 4.89, avg: 4.65 g/bird, 4.36, 4.60, avg: 4.48 g/bird,

Table 6. Heart weight (g/bird) of Japanese quail

Group	Sex		Average
	Male	Female	
A	1.49	1.9	1.70[d]
B	1.78	1.86	1.82[cd]
C	1.52	1.94	1.73[cd]
D	1.82	1.87	1.85[bc]
E	1.97	2.06	2.02[ab]
F	1.94	2.38	2.16[a]
G	1.81	2.3	2.06[ab]
H	2.09	2.26	2.18[a]
Average	1.80[b]	2.07[a]	--

	Treatments (T)	Sex (S)	T × S
S.E.±	0.1586	0.0793	0.2242
LSD 0.05	0.3194	0.1597	0.4516
P-Value	0.0160	0.0374	0.1355

Table 7. Liver weight (g/bird) of Japanese quail

Group	Sex		Total
	Male	Female	
A	4.02	4.42	4.22
B	4.29	4.41	4.35
C	4.19	4.47	4.33
D	4.18	4.64	4.41
E	4.36	4.6	4.48
F	4.47	5.56	5.06
G	4.41	4.89	4.65
H	4.37	5.75	5.02
Average	4.29	4.84	--

	Treatments (T)	Sex (S)	T × S
S.E.±	0.2468	0.1234	0.3491
LSD 0.05	0.4971	0.2486	0.7931
P-Value	0.7211	0.6045	0.4299

respectively. Liver weight was reduced in male, female birds and average in groups D; B, and C, i.e., 4.18, 4.64, avg: 4.33 g/bird; 4.29, 4.41, avg: 4.35 g/bird; 4.19, 4.47, avg: 4.33 g/bird, respectively. The least male, female, and average liver weight (4.02, 4.42, avg: 4.22 g/bird), respectively was recorded in control group A.

3.5.5 *Gizzard Weight of Quails (g/bird)*

The results showed that organic and inorganic zinc with vitamin E in various combinations had insignificant effect (P>0.05) on gizzard weight (Table 8). The gizzard weight of male, female birds and their average in group H was relatively higher (5.9, 5.34, avg: 5.62 g/bird), followed by the birds of groups F, G, and E with male, female gizzard weight and average of 5.52, 4.91, avg: 5.21 g/bird; 5.17, 5.11, avg: 5.14 g/bird, 4.27, 5.90, avg: 5.08 g/bird, respectively. Gizzard weight was reduced in groups D; B and C having male, female and average gizzard weight of 4.65, 5.25, avg: 4.95 g/bird; 5.31, 4.55, avg: 4.93 g/bird; 4.92, 4.72, avg: 4.82 g/bird, respectively. The lowest male, female

Table 8. Gizzard weight (g/bird) of Japanese quail

Group	Sex		Total
	Male	Female	
A	5.60	3.80	4.70
B	5.31	4.55	4.93
C	4.92	4.72	4.82
D	4.65	5.25	4.95
E	4.27	5.90	5.08
F	5.52	4.91	5.21
G	5.17	5.11	5.14
H	5.90	5.34	5.62
Weekly average	5.17	4.95	--

	Treatments (T)	Sex (S)	T × S
S.E.±	0.5121	0.2561	0.7242
LSD 0.05	1.0315	0.5157	1.4587
P-Value	0.7464	0.3935	0.0821

and average gizzard weight (5.60, 3.80, avg: 4.70 g/ bird), respectively was recorded in control group A.

3.5.6 Morphology of the Reproductive Tract

The data in relation to the above parameters of Japanese quails-fed diets containing diverse sources and levels of zinc in addition to vit-E as compared to control are shown in Table 9. The effect of diet on oviduct weight, oviduct length, ovary weight, follicle number as well as left and right testes weight was significant ($P<0.05$) and values for all these reproductive traits of Japanese quail were greater for birds of Group E, followed by the birds in groups H, E and B. Both left and testis weight in diets weights were equally affected by the diets; and similarly, the oviduct weight and length were equally affected by the Zinc + Vit-E based quail diets. Similarly, the follicular number also varied significantly with the inclusion of zinc and Vitamin E in the quail diet. However, the effect of organic zinc was more pronounced as compared to inorganic zinc when added to the quail diet in combination with Vitamin E. In the absence of Vitamin E, the reproductive female reproductive tract, ovary weight, and left and right testes of male quails showed greater adverse effects, even in the presence of zinc in their diet. However, the combined effect of organic Zinc + Vit-E on the reproductive traits of male and female quails was positive and significant.

Table 9. Morphology of intestinal villi of Japanese quail

Group	Jejunum				Ileum			
	JVH (mm)	JCD (mm)	JVH: CD	JVT (mm)	IVH (mm)	ICD (mm)	IVH: CD	IVT (mm)
A	0.45^{d}	0.047^{c}	9.58^{b}	0.122^{b}	0.34^{c}	0.051	6.67^{c}	0.111^{b}
B	0.51^{ab}	0.050^{a}	10.20^{a}	0.130^{ab}	0.41^{b}	0.051	8.04^{a}	0.120^{ab}
C	0.48^{c}	0.048^{b}	10.00^{a}	0.125^{b}	0.37^{bc}	0.051	7.25^{b}	0.119^{ab}
D	0.47^{c}	0.048^{b}	9.79^{b}	0.123^{b}	0.36^{bc}	0.051	7.06^{b}	0.113^{ab}
E	0.52^{a}	0.051^{a}	10.20^{a}	0.130^{ab}	0.43^{a}	0.051	8.43^{a}	0.123^{a}
F	0.53^{a}	0.052^{a}	10.19^{a}	0.135^{a}	0.44^{a}	0.052	8.46^{a}	0.123^{a}
G	0.50^{b}	0.049^{b}	10.20^{a}	0.133^{a}	0.39^{b}	0.051	7.65^{b}	0.118^{ab}
H	0.53^{a}	0.050^{a}	10.60^{a}	0.135^{a}	0.43^{a}	0.051	8.43^{a}	0.123^{a}
P-Value	*0.047**	*0.051**	*0.005***	*0.042**	*0.008***	*0.089*^{NS}	*0.033**	*0.044**

JVH=Jejunum villus height (mm); JCD=Jejunum crypt depth (mm); JCD:CD=Jejunum villus height to crypt depth ratio; JVT=Jejunum villus thickness (mm); IVH=Ileum villus height (mm); ICD=Ileum crypt depth (mm); IVH:CD=Ileum villus height-to-crypt-depth ratio; IVT=Ileum villus thickness (mm)

Table 10. Morphology of the reproductive tract of Japanese quail

Group	Oviduct weight (g)	Oviduct length (cm)	Ovary weight (g)	Follicle number	Left testes weight (g)	Right testes weight (g)
A	6.94	34.33	5.48	4.19	2.69	2.62
B	7.89	35.63	5.81	4.62	3.05	3.19
C	7.63	35.33	5.67	4.36	2.96	2.94
D	7.41	34.78	5.58	4.28	2.87	2.77
E	8.63	35.52	6.11	4.73	3.51	3.31
F	8.71	36.13	6.21	4.86	3.76	3.42
G	8.19	35.81	5.66	4.55	3.18	3.08
H	8.61	36.02	6.08	4.85	3.72	3.37
P-Value	*0.0473**	*0.0514**	*0.0357**	*0.0249**	*0.0083***	*0.0218**

4. DISCUSSION

Japanese quail is the source of meat that is most flavorsome, delicious, and appetizing in the avian species. There is enormous potential for commercial quail farming, but this component of the poultry sector is identically neglected in Pakistan. Due to a lack of research focus, no advancement in quail breeding-related aspects (incubation, housing, nutritional requirements) and health management under local environmental conditions has been reported [23]. Generally, commercial poultry is formulated by adding antioxidants for prevention against lipid peroxidation and oxidative rancidity during production [24]; and dietary antioxidants and cofactors help counteract the negative effects of oxidative stress in poultry birds [25]. Some substances including zinc and vitamin E have strong antioxidant characteristics. Vit-E is one of the most powerful antioxidants that is added to poultry feed to improve performance, strengthen immunological status, improve the quality of meat and egg, and increase the vitamin E content of meat [26]. Similarly, Zn is an effective antioxidant and essential trace mineral in organisms having an important role in growth, bone development, enzyme structure and function, and eggshell formation in poultry. The study showed that Zinc in addition to Vitamin E (Zn + Vit-E) had a significant effect on feed intake, LBW, filled intestine weight, carcass, and giblets ($P<0.05$); while the treatment effect was insignificant ($P>0.05$) on intestine empty weight, cecal length, liver weight, gizzard weight, and mortality. The quail showed a preference to consume feed with organic zinc (picolinate) in addition to Vit-E over inorganic zinc ($ZnSO_4$) +Vit-E. Absence of zinc as picolinate in feed caused a significant decrease in average feed intake in the presence of $ZnSO_4$. The quails feed choice was affected significantly due to presence or absence of vitamin E. This indicates that inclusion of organic zinc (picolinate) was preferred by quails over $ZnSO_4$; while birds were pleased to take more feed when Vitamin E was added. In most cases, there was similarity ($P>0.05$) in the feed intake of quails in all groups with minute difference indicating that the growth and blood physiology of quails was improved by dietary Zn + Vit-E without additional consumption of feed. Combination of Zn*O* 50 + Zn*I* 30 + VE 25 resulted in better overall bird performance. Japanese quail is known for rapid growth and high body weight [27-28]. As an antioxidant, Vit-E has an effective role as an antioxidant in a biological system and individually explicates its antioxidant function in lipid phases by restoring antioxidant properties [29, 30-31] observed that Quail's body weight rose when dietary vitamin E levels were high; earlier research also came to the same conclusion that dietary vitamin e benefited quail development under heat stress conditions. The benefit of vitamin E on chicken performance only manifests under environmental stress conditions; it is undetectable under conditions of normal temperature [32].

5. CONCLUSION

The Zn + Vit-E significantly influenced the feed intake, LBW, filled intestine weight, intestine length, carcass weight and heart weight ($P<0.05$); while the treatment effect was insignificant ($P>0.05$) on liver weight, gizzard weight, and mortality. The quail showed a preference to consume feed with organic zinc (picolinate) in addition to Vit-E over inorganic zinc ($ZnSO_4$) +Vit-E. Absence of zinc as picolinate in feed caused a significant decrease in average feed intake in the presence of $ZnSO_4$. The quails feed choice is significantly affected due to the presence or absence of Vitamin E. This indicates that inclusion of organic zinc (picolinate) was preferred by quails over $ZnSO_4$; while birds were pleased to take more feed when Vitamin E was mixed. The dietary Zn + Vit-E inclusion significantly ($P<0.05$) increased the relative length of gut segments, villi height, villus thickness, the villi height to crypt depth proportion in jejunum and ileum and the number of goblet cells in different parts of the intestine of quails.

6. CONFLICT OF INTEREST

The authors declared no conflict of interest.

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