Influence of Organic, Inorganic Zinc and Vitamin-E Alone or In Combination on Nutrient Digestibility and Meat Quality of Japanese Quail

M. Akbar Nasar*[a], Nasir Rajput[b], Azizullah Memon[c], Athar Mahmud[d], Muhammad Fahim[e]

[a,b,c,e]Department of Poultry Husbandry, Faculty of AH&VS, Sindh Agriculture Unievrsity , Tandojam, Pakistan
[d]Department of Poultry Production, University of Veterinary & Animal Sciences, Lahore, Pakistan
*Corresponding author Email: * akbarnasar1976@gmail.com

Abstract

The investigation was done to investigate the comparative effect of zinc in organic (ZnO) and inorganic (ZnI) forms in addition to vitamin-E alone or in combination on nutrient digestibility and meat quality of Japanese quail. The feed formulation for the experimental birds included 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. On all the qualities under study, the results showed a treatment effect that was statistically significant (P 0.05). The nutrient digestibility was remarkably improved when organic Zn+VE; but organic Zn was more digestible than inorganic Zn; while VE was most effective to improve nutrient digestibility in quails. The thigh meat of birds in groups H and F contained higher dry matter (29.88 and 29.82%), lower ash (1.73 and 1.62%), higher CP (22.49 and 22.31%), moderate ether extract (3.15 and 3.35%), respectively; showed similar trend for breast meat contained higher dry matter (29.99 and 29.81%), lower ash (1.70 and 1.47%), higher CP (23.49 and 23.77%), slightly higher ether extract (3.42 and 3.35%), respectively. The meat quality of male birds was superior to the female.

Key words: Dietary zinc, Japanese quail, Meat quality, Nutrient digestibility, Vitamin-E, Zinc forms

Introduction

A little game bird utilized extensively and commercially for meat production is the Japanese quail (Nasar et al., 2016). The quails achieve rapid sexual maturity; females mature around 6 weeks of their age; while reach to full egg production at the age of 50 days. The Japanese quails can produce up to four generations in a year, and because of rapid production of delicious meat producing bird makes it most effective and suitable poultry bird. The Japanese quail (*C. coturnix Japonica*) and the American quail are the two species of quail that are typically farmed on a commercial scale (*C. coturnix*). It is typical for quail to migrate from Asia to Europe and from Europe to Asia. The Japanese quail is a member of the Phasianidae family (Nasar et al., 2016; Nagalakshmi et al., 2011).

The Japanese quail is amongst species found in East Asia and supposed to be migratory, breeding in southeastern Siberia, northern Japan and the Korean Peninsula. This specie is abundant across most of its range; and it is primarily raised for producing eggs and meat, making it a good dual-purpose bird (Maurice & Bolla, 2006). The female bird's body colour is similar to the male's, with the exception that it has longer feathers on its throat and upper breast. Additionally, the light brown breast feathers have the distinctive black stippling. (Takaoki, 2007). A mature female typically lays one egg every cycle that weighs about 10 grams and has 158 calories, 74.6% water, 13.1% protein, 11.2% fat, and 1.1% total ash. Japanese quail eggs have a yellowish-brown colour, and its composition is as follows: 0.59 ml of calcium, 220 ml of phosphorus, and 3.8 ml of iron. This product contains 300 IU of vitamin A, 0.12 mg of vitamin B1, 0.85 mg of vitamin B2, and 0.10 mg of nicotinic acid. It also contains 0.85 mg of vitamin B1 (Guryeva, 1993). Being a smallest member of poultry and possession of above said characteristics, Japanese quails are now a day's widely used for meat production on commercial scale (Abas et al., 2004; Agunua et al., 2010). More encouraging element in quail farming is smaller capital investment as compared to other poultry birds such as duck and chicken; while profit margin seems to be similar (Al-Marzooqi et al., 2015).

Due to a lack of study on quail breeding, incubation, housing, nutritional requirements, general management, and disease prevention in the local environment, quail farming offers a tremendous amount of potential, it has been ignored in Pakistan's poultry sector. This is despite the fact that it has the potential to significantly contribute to the national economy (Akram et al., 2008). In the past, antioxidants have been included in commercial feeds in an effort to stop the potential oxidative rancidity and lipid peroxidation brought on by exposure to oxygen. In addition, the use of antioxidants has risen due to the incorporation of polyunsaturated fat-rich components into the formulation of animal feeds that presents an additional advantage. It has been established that antioxidants perform a broad variety of biological roles, including several that are relevant to both animals and humans (Kalam et al., 2012). Oxidative stress and a subsequent decline in performance can be brought on in chickens by a variety of factors, including those related to their nutrition, pathology, physiology, and their environment (Salami et al., 2015). As a consequence of this, it has been discovered that hens can experience a reduction in the detrimental effects of oxidative stress when they consume antioxidants (Salami et al., 2015).

Literature Review

By using antioxidants, reactive oxygen species can have their damaging effects scavenged, removed, reduced, or muted (Majid et al., 2019). The generation of reactive oxygen species, which is brought on by the frequent occurrence of lipid peroxidation, has a detrimental effect on the productivity of birds. When the body's capacity to neutralize free radicals is less than the rate of reactive oxygen species generation, oxidative stress, which is detrimental to avian performance, develops (Khan et al., 2012). According to the results of scientific research, the body's physiology must be in a condition of equilibrium for antioxidants to effectively remove free radicals from the body. Zinc, selenium, vitamin E, and vitamin C are just a few examples of substances that are packed with antioxidants. Vitamin E, an antioxidant, has been added to animal feed in order to increase performance, boost immunity, Enhance the quality of meat and eggs, and increase the amount of vitamin E present in animal-based foods so that more people can consume it (Flachowsky, 2000). Because avian particularly chickens and turkeys are unable to create vitamin E on their own, the only way for people to meet their needs is to consume foods that are vitamin-rich (Chan & Decker, 1994). Due to its antioxidant characteristics, vitamin E is added to chicken feed, which helps to combat the free radicals that are created when the bird is exposed to heat stress (Ramnath et al., 2008). Free radicals that are present in cell membranes are scavenged by vitamin E, an antioxidant that has been shown to reduce the risk of tissue deterioration. The combined effects of these two compounds can considerably minimize the production of reactive oxygen species which are especially efficient in the aqueous and lipid phases of the cell membrane. The antioxidant effects of zinc and vitamin E supplementation can help reduce some physiological symptoms and increase thermo tolerance (Ciftci et al., 2005).

In poultry production, oxidative stress may happen by a variety of circumstances, which commonly included high temperatures, health problems, and poor feed quality (Wang et al., 2009). Oxidative stress can have a negative impact on spermatogenesis, egg production, egg quality storage, and hatchling viability in broiler breeder production (Lin et al., 2008). Increasing the antioxidant capacity of the body can be accomplished by consuming foods that include antioxidants, such as vitamin E (Reis et al., 2009).

In the diets of animals, there are numerous types of vitamin E supplements that can be discovered, and this is done to maintain the reproductive, muscular, cardiovascular, neurological, and immunological systems in good condition (Habibian et al., 2014). In addition to this, research indicates that the overall quality of the meat has increased, membrane lipid per-oxidation has decreased, and an increased number of immune cells have been activated (Hashizawa et al., 2013). The performance of the bird is improved by increasing the vitamin E content of its meal by breaking the process of oxidation that occurs naturally in the body (Jena et al., 2013). The most prevalent form of vitamin E, known as -tocopherol, is composed of many different isomers of the tocopherol molecule. The most common type of vitamin E added to commercial chicken diets is tocopherol, while natural or synthetic vitamin E may also be used. It is possible that increasing the quantity of vitamin E that is added to broiler or breeder meals would increase the amount of vitamin E that is found in the yolk, and as a consequence, the amount of vitamin E that is found in the birds themselves (Surai et al., 2001). The availability of antioxidants appears to be a constraining factor for birds in their natural environments, given that taking antioxidant supplements improves the transfer of those nutrients to eggs, which in turn has a beneficial impact on some characteristics of the offspring (Biard et al., 2005).

When it comes to antioxidants, zinc (Zn) stands out because it is both a powerful antioxidant and a vital trace element for all living things. Zinc is necessary for the successful development of eggshells, growth, bone development, enzyme structure, and other processes in chicken birds. It's common for the quantity of zinc that laying hens need to have in their diets to be more than what egg producers add in as a premix to their food for them. As a direct consequence of this method, there have been questions raised regarding the genetic potential of existing breeds as well as the risks to the environment (Ao et al., 2013). The administration of Zn results in a significant rise in the blood concentrations of vitamins C and E, as well as zinc, in chickens. When it comes to the body's natural defences against free radical damage, zinc plays one of the most important roles (Sahin & Kucuk, 2003). Zinc, which affects fat metabolism, works well as an antioxidant when paired with vitamin E to counteract the harmful effects of heat stress. Combining vitamin E, a well-known antioxidant, with zinc, an antioxidant agent, can boost the activity of antioxidant enzymes. Zinc and vitamin E together increase the general health and performance of birds by strengthening their immune systems and nutrition (Bou et al., 2004).

By examining the impacts on nutrient digestibility and meat quality of Japanese quails, the current study was conducted to ascertain the effects of Zn and vitamin E alone or in combination supplementation to the food on the metabolism.

Methodology

Several studies were conducted over the course of six months at the Avian Research & Training (ART) Center, Department of Poultry Production, University of Veterinary and Animal Sciences (UVAS), Lahore. The mother institution (Department of Poultry Husbandry,) received all of the experimental data. Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, Tandojam received all of the experimental data for compilation. A total of 960-dayold quail chicks were purchased from ART hatchery, UVAS Lahore. Under a properly randomised methodology, these chicks were divided into eight (08) distinct nutritional treatments (CRD). Each treatment group was then divided into four smaller groups, each containing thirty chicks (Table 1). The young quail were raised in cages in an open-sided building with unfettered access to food and water.

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

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

8 treatments * 4 Replicates * 30 Birds in each replicate = 960 birds
***1U =** 1U/kg = 0.67mg dl-ἀ-tocopheryl acetate

The birds were fed a beginning basal diet providing 2800 kcal/kg of metabolizable energy and 22% crude protein (CP) (ME). B, C, D, E, F, G, and H are the seven experimental diets that were developed (Table 2). According to NRC norms, the ration was made by Hi-Tech Feed Industries (Pvt.), Lahore, Pakistan (1994).

Table 2: The basal diet's components and 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-Methionin	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
L-Theronine	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

Nutrient Digestibility

One chick from each replicate was moved to a different pen after 36 days of development. Feces were collected every morning, noon, and night for three days straight (39 to 41 for finisher phase) following the three-day adaption period and were then stored at -200C for future examination. The AOAC method was used to determine the digestibility of the nutrients CP, CF, EE, ME, DM, and Ash.

Proximate analysis

At the age of 6 weeks, two birds (one male and one female) were randomly selected from each replication, weighed, and killed to conduct a proximate analysis to look at the impact of the therapy on the quality of the meat.

In order to determine the contents of dry matter, ash, CP, and ether extract, proximate analysis of the meat samples was performed using the Official Methods of A.O.A.C (1995) in the Nutrition Laboratory, Department of Animal Nutrition of the University of Veterinary And Animal Sciences, Lahore, at the end of the sixth week of the experimental period. The proximate analysis procedure used for quail meat is described in detail as follows:

Dry matter

The following formula was used to determine the dry matter percentage of the meat sample:

$$DM \% = 100 \% \text{ Moisture}$$

Ash: A pre-weighed, tarred, and known-amount meat sample (W1) was taken in the crucible. It was heated over an oxidising flame until the smoke dissipated. The crucible was then put in a muffle furnace and heated to around 600 °C, where the organic materials was completely oxidised. The amount of ash (W2) was measured, and the formula below was used to calculate the percentage of ash:

$$Ash\% = W1/W2 \times 100$$

Crude protein

In a Kjeldahl flask, one gramme of dried and crushed beef sample was digested with five grammes of a catalyst mixture made of K_2SO_4, $CuSO_4$, and $FeSO_4$ (90:10:1) and thirty millilitres of concentrated sulphuric acid (H_2SO_4). The flasks' contents were heated until a clear, transparent solution was produced. After chilling, distilled water was used to dilute the flask's contents up to 250 ml in a volumetric flask. In a micro Kjeldahl distillation unit, 10 ml of the diluted solution was combined with 10 ml of a 40% sodium hydroxide solution. In 10 ml of 2% boric acid solution with 2 drops of methyl red as an indicator, the ammonia thus created was collected. To calculate the amount of NH_3 evolved, the distillate was titrated against 0.1N sulfuric acid. The following formula was used to get the nitrogen percentage:

Nitrogen percentage equals 0.1N H_2SO_4 0.0014 250/W1 10100

The formula below was used to calculate the sample's crude protein percentage:

$$Protein\%\ Crude = N\%\ 6.25$$

Ether extracts

A sample of oven-dried meat with a known weight (W1) was taken in an extraction thimble. Cotton that had no fat was used to plug it. In Soxhlet's apparatus, the sample was extracted using petroleum ether at a temperature range of 40 to 60°C with the condensation rate set at 80 drops per minute. It took almost six hours to complete the operation. The receiving flask's contents were transferred to a Petri plate that had been tarred and weighed beforehand. By baking it at 60 degrees Celsius, ether was evaporated until it reached a consistent weight (W2).

The following formula was used to compute the percentage of ether extract:

$$W2/W1100 = Ether\ Extract$$

Results and Findings

Nutrient digestibility

The use of dry matter (DM), crude protein (CP), ether extracts (EE), crude fibre (CF), crude ash (CA), and nitrogen free extracts (NFE) was used to measure the nutrient digestibility when feeding Japanese quail with organic and inorganic Zn+VE; and found that nutrient digestibility was significantly associated with the dietary Zn and VE variability in the quail diet. The DM (dry matter) digestibility in quails was highest (73.25%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by the quails in groups B (Zn*O*

25+Zn*I*0+VE 0), E (Zn*O*25+Zn*I*15+VE 0) and D (Zn*O*0+Zn*I*0+VE 12) with average DM digestibility of 72.66, 71.54 and 70.59%, respectively. It was noted that DM digestibility was adversely affected by inclusion of both organic and inorganic Zn, and vit-E inclusion improved the DM digestibility in quails. The digestibility of CP (crude protein) in quails was highly improved (82.22%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by the quails in groups B (Zn*O* 25+Zn*I* 0+VE 0), C (Zn*O*0+Zn*I* 15+VE 0) and D (Zn*O* 0+Zn*I* 0+VE 12) with average CP digestibility of 80.25, 79.12 and 78.66% respectively (Table 4). The crude protein digestibility was higher in groups receiving organic Zn or vitamin C; while addition of Zn in both forms showed adverse effect on CP digestibility.

The EE (Ether extracts) digestibility increased significantly (85.52%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by the quails in groups B (Zn*O* 25+Zn*I* 0+VE 0), G (Zn*O*0+Zn*I* 15+VE 12) and H (Zn*O*25+Zn*I*15+VE 12) with average EE digestibility of 82.65, 82.19 and 80.65% respectively. The quails receiving organic Zn in addition to Vit-E reflected improved EE digestibility over the rest of treatment groups. The CF (Crude fiber) digestibility increased greatly in quails (35.66%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by the birds in groups B (Zn*O* 25+Zn*I* 0+VE 0), G (Zn*O* 0+Zn*I* 15+VE 12) and E (Zn*O* 25+Zn*I* 15+VE 0) with CF digestibility of 34.65, 32.91 and 32.88 % respectively. The nutrient digestibility pattern for CF in quails showed slight change over DM, CP and EE digestibility but similar trend was recorded for groups F and B. The crude ash (CA) digestibility in quails was highest (58.66%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by groups E (Zn*O* 25+Zn*I* 15+VE 0), G (Zn*O* 0+Zn*I* 15+VE 12) and H (Zn*O* 25+Zn*I* 15+VE 12) with average CA digestibility of 54.88, 54.26 and 54.10 % respectively. Some similarity in CA digestibility trend was seen when compared with CF digestibility pattern in quails. The digestibility of NFE (Nitrogen free extracts) was also determined in quails and the data showed significantly highest digestibility (83.75%) in group F (Zn*O* 25+Zn*I* 0+VE 12), followed by the groups B (Zn*O* 25+Zn*I* 0+VE 0), E (Zn*O* 25+Zn*I* 15+VE 0) and G (Zn*O*0+Zn*I* 15+VE 12) with average NFE digestibility of 82.25, 81.86 and 81.65% respectively.

Table 3: Nutrient digestibility in Japanese quails (%) fed on ration containing different combinations of organic and inorganic Zn + VE

Group	Zn*O*+Zn*I*+VE	Nutrients					
		DM	CP	EE	CF	CA	NFE
A	0 + 0 + 0	67.25^{d}	70.21^{d}	71.05^{d}	28.65^{d}	50.50^{c}	79.65^{c}
B	25 + 0 + 0	72.66^{ab}	80.25^{ab}	82.65^{b}	34.65^{a}	54.06^{b}	82.25^{ab}
C	0 + 15 + 0	69.45^{bc}	79.12^{b}	80.14^{c}	32.55^{b}	53.70^{b}	79.12^{c}
D	0 + 0 + 12	70.59^{b}	78.66^{bc}	79.65^{c}	31.50^{c}	53.74^{b}	80.66^{bc}

E	25 + 15 + 0	71.54[ab]	78.44[bc]	80.11[c]	32.88[b]	54.88[b]	81.86[b]
F	25 + 0 + 12	73.25[a]	82.22[a]	85.52[a]	35.66[a]	58.66[a]	83.75[a]
G	0 + 15 + 12	69.54[b]	76.50[c]	82.19[b]	32.91[b]	54.26[b]	81.65[b]
H	25 + 15 + 12	68.88[c]	76.20[c]	80.65[c]	32.02[b]	54.10[b]	81.56[b]
P-Value		0.0276*	0.0068**	0.0017**	0.0298*	0.0169**	0.0357*

DM=Dry Matter CP=Crude Protein EE=Ether Extracts CF=Crude Fiber CA=Crude AshNFE=Nitrogen Free Extracts

Proximate analysis

Dry matter content in thigh meat

The effect of dietary organic zinc (Zn*O*) and inorganic zinc (Zn*I*) with vitamin E (VE) combinations on dry matter content of thigh meat was significant (P<0.05); and insignificant (P>0.05) between male and female samples. The thigh meat dry matter content of male, female quails and their average in group H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg) was maximum (29.71, 30.05, avg: 29.88%), followed by the meat samples of groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg) and E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) having male, female and average thigh meat dry matter contents of 29.65, 29.99, avg: 29.82%;28.69, 28.49, avg: 28.59%;28.56, 27.48, avg: 28.02%, respectively. The dry matter content in thigh meat was relatively lower for male, female birds and average in groups D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg); B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg) and C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg), i.e. 28.04, 27.96, avg: 28.0%; 28.64, 27.25, avg: 27.95%; 26.34, 27.42, avg: 26.88%, respectively.

Dry matter content in breast meat

The dry matter in breast meat was significantly influenced Zn forms and VE combinations as well as female and female breast meat (P<0.05). The breast meat dry matter in male, female birds and average in group H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg) was highest (30.33, 29.65, avg: 29.99 %), followed by the groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg) and E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) having male, female and average breast meat dry matter contents of 29.87, 29.74, avg: 29.81%; 29.85, 28.22, avg: 29.04 %; 30.11, 28.78, avg: 29.45 %, respectively. Dry matter content in breast meat was relatively lower for male, female birds and average in groups D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg); B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg) and C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg), i.e. 29.14, 29.32 avg: 29.23 %; 28.58, 28.11, avg: 28.35 %; 29.23, 29.18, avg: 29.21 %, respectively. The least male, female and average dry matter content in breast meat (27.99, 26.75, avg: 27.37 %), respectively was recorded in control group A (control).

Ash content in thigh meat

The effect of Zn +VE on ash content of thigh meat was insignificant (P>0.05). The thigh meat ash content of male, female quails and their average in group B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg) was minimum (1.27, 1.78, avg: 1.52 %), followed by the meat samples of groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), A (Zn*O* 0+Zn*I* 0+VE 0 mg/kg) and G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg) having male, female and average thigh meat ash contents of 1.68, 1.56, avg: 1.62%; 1.65, 1.69, avg: 1.67%; 1.73, 1.63, avg: 1.68%, respectively. The ash content in thigh meat was relatively higher for male, female birds and average in groups D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg); H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg) and C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg), i.e. 1.77, 1.70, avg: 1.73%; 1.79, 1.68, avg: 1.73%; 1.62, 1.61, avg: 1.72%, respectively. The highest male, female and average ash content in thigh meat (1.82, 1.79, avg: 1.81%), respectively was recorded in E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg).

Table 4: Dry matter (%) in thigh and breast meat, ash content (%) in thigh meat of Japanese quail of either sex as influenced by different Zn+VE levels

Grp	Zn*O*+Zn*I*+VE	DM (thigh meat)			DM (breast meat)			Ash (thigh meat)		
		Male	**Female**	**Avg**	**Male**	**Female**	**Avg**	**Male**	**Female**	**Avg**
A	0 + 0 + 0	27.07	26.51	26.79^{c}	27.99	26.75	27.37^{c}	1.65	1.69	1.67
B	25 + 0 + 0	28.64	27.25	27.95^{b}	28.58	28.11	28.35^{bc}	1.27	1.78	1.52
C	0 +15 + 0	26.34	27.42	26.88^{c}	29.23	29.18	29.21^{ab}	1.62	1.61	1.72
D	0 + 0 +12	28.04	27.96	28.00^{b}	29.14	29.32	29.23^{ab}	1.77	1.70	1.73
E	25 +15 + 0	28.56	27.48	28.02^{b}	30.11	28.78	29.45^{a}	1.82	1.79	1.81
F	25 + 0 +12	29.65	29.99	29.82^{a}	29.87	29.74	29.81^{a}	1.68	1.56	1.62
G	0 +15 +12	28.69	28.49	28.59^{b}	29.85	28.22	29.04^{ab}	1.73	1.63	1.68
H	25 +15 +12	29.71	30.05	29.88^{a}	30.33	29.65	29.99^{a}	1.79	1.68	1.73
Weekly average		**28.34**	**28.16**	**--**	**29.39^{a}**	**28.72^{b}**	**--**	**1.67**	**1.70**	**--**

LSD 0.05 1.0012 1.0115
0.3548
P-Value 0.0002 0.0001
0.8529

Note: **Zn*O*** = Organic zinc (Zinc Picolinate), **Zn*I*** = Inorganic zinc ($ZnSO_4$ mg kg^{-1}), **VE**=Vitamin-E (IU kg^{-1})
****=**Highly Significant (P<0.01), **NS=**Non-Significant (P>0.05), **F-Ratio**=Fisher's F-test, **P-Value**=Probability value

Ash content in breast meat

The treatment effect on ash content in breast meat of male and female Japanese quail (Table 2) was significant (P<0.05) and insignificant (P>0.05) for bird sex. The breast meat ash content of male, female quails and their average in group B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg) was lowest (1.30, 1.51, avg: 1.41%), followed by the meat samples of groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) and D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg) having male, female and average breast meat ash contents of 1.57, 1.37, avg: 1.47%; 1.36, 1.60, avg: 1.48%; 1.80, 1.58, avg: 1.69%, respectively. Comparatively higher ash content in breast meat for male, female birds and average was observed in groups H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg); A (Zn*O* 0+Zn*I* 0+VE 0 mg/kg) and G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg), i.e. 1.69, 1.72, avg: 1.70%; 1.54, 1.89, avg: 1.71%; 1.72, 1.72, avg: 1.72%, respectively. The highest male, female and average ash content in breast meat (1.75, 1.91, avg: 1.83%), respectively was recorded in C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg).

Crude protein (CP) content in thigh meat

The effect of dietary Zn +VE in varied concentrations on CP content of thigh meat was significant (P<0.05). The thigh meat CP content of male, female quails and their average in group H (Zn*O* 25+Zn*I*15+VE 12 mg/kg) was highest (23.31, 21.59, avg: 22.49%), followed by the birds in groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), G (Zn*O* 0+Zn*I*15+VE 12 mg/kg) and E (Zn*O*25+Zn*I* 15+VE 0 mg/kg) having male, female and average thigh meat CP contents of 23.34, 21.67, avg: 22.31%; 23.19, 21.35, avg: 22.27%; 23.02, 21.36, avg: 22.19%, respectively. The CP content in thigh meat was considerably lower for male, female birds and average in groups B (Zn*O*25+Zn*I*0+VE 0 mg/kg); C (Zn*O*0+Zn*I* 15+VE 0 mg/kg) and D (Zn*O* 0+Zn*I*0+VE 12 mg/kg), i.e. 23.0, 21.28, avg: 22.14%; 22.91, 20.83, avg: 21.87%; 23.13, 20.61, avg: 21.87%, respectively. The lowest male, female and average CP content in thigh meat (21.71, 21.40, avg: 21.55%), respectively was determined in group A (control).

Crude protein (CP) content in breast meat

The treatment effect on CP content of breast meat of Japanese quail was significant (P<0.05). The breast meat CP content of male, female birds and their average in group F (Zn*O* 25+Zn*I*0+VE 12 mg/kg) was highest (24.80, 22.74, avg: 23.77%), followed by the birds in groups G(Zn*O* 25+Zn*I*15+VE 12 mg/kg), H (Zn*O* 0+Zn*I* 15+VE 12 mg/kg) and E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) having male, female and average breast meat CP contents of 24.68, 22.84, avg: 23.76%; 24.28, 22.70, avg: 23.49%; 24.29, 22.70, avg: 23.50%, respectively. CP content followed a decreasing trend for male, female birds and average in groups B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg); C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg) and D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg), i.e. 24.09, 22.52, avg: 23.30%; 23.75, 22.73, avg: 23.24%; 23.67, 22.58, avg: 23.13%, respectively. The lowest male, female and average CP content in breast meat (23.94, 22.25, avg: 23.10%), respectively was found in group A (control).

Table 5: Ash, CP (thigh) and CP (beast) contents (%) in meat of Japanese quail of either sex as influenced by different Zn+VE levels

Grp	Zn*O*+Zn*I*+VE	Ash (breast meat)			CP (thigh meat)			CP (Breast meat)		
		Male	Female	Avg	Male	Female	Avg	Male	Female	Avg
A	0 + 0 + 0	1.54	1.89	1.71^{ab}	21.71	21.40	21.55^{c}	23.94	22.25	23.10^{b}
B	25 + 0 + 0	1.30	1.51	1.41^{c}	23.00	21.28	22.14^{ab}	24.09	22.52	23.30^{b}
C	0 + 15 + 0	1.75	1.91	1.83^{a}	22.91	20.83	21.87^{bc}	23.75	22.73	23.24^{b}
D	0 + 0 +12	1.80	1.58	1.69^{ab}	23.13	20.61	21.87^{bc}	23.67	22.58	23.13^{b}
E	25 + 15 + 0	1.36	1.60	1.48^{bc}	23.02	21.36	22.19^{ab}	24.29	22.70	23.50^{ab}
F	25 + 0 +12	1.57	1.37	1.47^{bc}	23.34	21.67	22.31^{a}	24.80	22.74	23.77^{a}
G	0 + 15 +12	1.72	1.72	1.72^{ab}	23.19	21.35	22.27^{ab}	24.68	22.84	23.76^{a}
H	25 + 15 +12	1.69	1.72	1.70^{ab}	23.31	21.59	22.49^{a}	24.28	22.70	23.49^{ab}
Weekly average		**1.59**	**1.66**	--	**22.95^{a}**	**21.26^{b}**	--	**24.19^{a}**	**22.63^{b}**	--
LSD 0.05		0.4256			0.2886			0.5516		
P-Value		0.0094			0.0451			0.0165		

Ether extracts (EE) content in thigh meat

The EE contents of Japanese quail thigh meat due to dietary Zn+VE at various concentrations was significant (P<0.05). The thigh meat EE content of male, female quails and their average in group F (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) was highest (3.43, 3.27, avg: 3.35%), followed by the birds in groups B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg), G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg) and H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg) having male, female and average thigh meat EE contents of 3.44, 2.88, avg: 3.16%; 3.23, 3.07, avg: 3.15%; 3.36, 2.93, avg: 3.15%, respectively (Table 3). The EE content in thigh meat was relatively lower for male, female birds and average in groups C (Zn*O*0+Zn*I*15+VE 0 mg/kg); E (Zn*O*25+Zn*I* 15+VE 0 mg/kg) and D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg), i.e. 3.68, 2.61, avg: 3.14%; 3.21, 3.0, avg: 3.11%; 3.15, 2.99 avg: 3.07%, respectively. The least male, female and average EE content in thigh meat (2.99, 3.01, avg: 3.0%), respectively was noted in control control group (A).

Ether extracts (EE) content in breast meat

The influence of bird sex on EE content of breast meat was significant (P<0.05) and insignificant (P>0.05) for Zn+VE based treatments. The breast meat EE content of male, female quails and average in group H (Zn*O* 25+Zn*I* 15+VE 12 mg/kg) was highest (3.62, 3.21, avg: 3.42%), followed by the birds in groups F (Zn*O* 25+Zn*I* 0+VE 12 mg/kg), D (Zn*O* 0+Zn*I* 0+VE 12 mg/kg) and B (Zn*O* 25+Zn*I* 0+VE 0 mg/kg) having male, female and average breast meat EE contents of 3.51, 3.19, avg: 3.35%;

3.46, 3.14, avg: 3.30%; 3.63, 2.94, avg: 3.28%, respectively (Table 3).The breast meat EE content followed further decrease in male, female birds and average in groups C (Zn*O* 0+Zn*I* 15+VE 0 mg/kg); E (Zn*O* 25+Zn*I* 15+VE 0 mg/kg) and G (Zn*O* 0+Zn*I* 15+VE 12 mg/kg), i.e. 3.52, 3.01, avg: 3.27%; 3.40, 3.14, avg: 3.27%; 3.35, 3.07 avg: 3.21%, respectively. The lowest EE content in in breast meat of male, female birds and average was 3.21, 2.68, avg: 2.94%), respectively in control group.

Table 6: Ether extract (EE) in thigh and beast meats (%) of Japanese quail of either sex as influenced by different Zn+VE levels

Grp	Zn*O*+Zn*I*+VE	EE % (thigh meat)			EE % (breast meat)		
		Male	**Female**	**Avg**	**Male**	**Female**	**Avg**
A	0 + 0 + 0	2.99	3.01	3.00	3.21	2.68	2.94
B	25 + 0 + 0	3.44	2.88	3.16	3.63	2.94	3.28
C	0 + 15 + 0	3.68	2.61	3.14	3.52	3.01	3.27
D	0 + 0 +12	3.15	2.99	3.07	3.46	3.14	3.30
E	25 + 15 + 0	3.21	3.00	3.11	3.40	3.14	3.27
F	25 + 0 +12	3.43	3.27	3.35	3.51	3.19	3.35
G	0 + 15 +12	3.23	3.07	3.15	3.35	3.07	3.21
H	25 + 15 +12	3.36	2.93	3.15	3.62	3.21	3.42
Weekly average		**3.31**^{a}	**2.97**^{b}	--	**22.95**^{a}	**21.26**^{b}	--

LSD 0.05 0.3609
0.3288
P-Value 0.7213
0.2037

Discussion

The research demonstrated that dietary vitamin E improves nutrition digestion and metabolic utilization by protecting proteins from oxidative denaturation (Ahmadu et al., 2016). Sigolo et al. (2021) It has been suggested that high dosages of vitamins E and C combined in the diet of quail may interact to promote overall animal welfare and newborn development. The organic Zn+VE proved to be most effective to improve thigh meat CP contents; while individual use of inorganic zinc or vit-E resulted in lowest thigh and breast meat CP content. The thigh meat of male quails contained higher CP content as compared to their female counterparts. The quality of breast meat was relatively superior to thigh meat; while organic Zn+Vit-E resulted in more positive impact on meat quality than inorganic Zn+Vit-E combination.

The study further showed that the organic Zn proved to be better than inorganic Zn source in addition to Vit-E . The incorporation of Zn and Vitamin E in quail diets in various combinations was found to have a significant and advantageous impact on growth, nutrient digestibility, and meat quality.

Conclusion

It was determined that the quail faeces samples given dietary Zn+vit-E with various combinations of organic and inorganic zinc were determined for nutrient digestibility and the results showed that all the related parameters including DM, CP, EE, CF, CA and The therapies had a substantial impact on NFE (P 0.05). When organic Zn was introduced to feed, the digestibility was considerably enhanced. In addition to vit-E; and organic Zn was more digestible than the inorganic Zn; while vit-E was most effective to improve nutrient digestibility in quails.

Further analysis revealed that, whereas ether extract remained unaffected ($P>0.05$), Zn+vit-E based treatment combinations significantly altered the dry matter, ash, and crude protein in thigh and breast meat. Compared to thigh meat, the quality of the breast meat was noticeably better; while organic Zn+Vit-E resulted in more positive impact on meat quality than inorganic Zn+vit-E combination. The organic Zn+VE proved to be most effective to improve thigh meat CP contents; while individual use of inorganic zinc or vit-E resulted in lowest thigh and breast meat CP content. The thigh meat of male quails contained higher CP content as compared to their female counterparts.

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