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The Effect of Supplementation of Organic Copper to Commercial Quail Diets on Performance, Egg Quality and Haematological Parameters

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ABSTRACT

The aim of this study was to investigate the effects of organic copper supplementation (0, 5, 10 and 20 mg/kg) in the commercial diet on performance, egg quality and haematological parameters in laying quails. In this 10-week trial, a total of 80 laying quails, aged 22 weeks, were randomly distributed among four experimental groups. Each experimental group contained four replicates of five female birds each. The addition of organic copper to the diets did not statistically affect egg production, egg weight, egg mass, feed conversion ratio, damaged eggs, egg shape index, Haugh unit, and blood parameters except neutrophils and mean corpuscular haemoglobin. Compared to other groups, body weight change was decreased by the addition of 20 mg/kg organic copper, and feed intake was decreased by the addition of 10 mg/kg copper in the quails. The addition of 20 mg/kg of organic copper to the quail diets significantly decreased the eggshell breaking strength and eggshell weight, while it significantly increased the eggshell thickness compared with the control group. The neutrophil and mean corpuscular haemoglobin were increased by the addition of 10 and 20 mg/kg organic copper, respectively, with compare to other groups. It can be said that up to 10 mg / kg of organic copper can be added to commercial quail diets, but its addition at 20 mg/kg negatively effects on some blood parameters as neutrophil and mean corpuscular haemoglobin in quails.

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Introduction

The copper (Cu) is an essential element in poultry nutrition. The copper is required for the use of iron in haemoglobin synthesis, it is take part in the different enzyme systems such as cytochrome A, catalase, thyrosinase, monoamine oxidase, ascorbic acid oxidase, uricase, superoxide dismutase, lysyl oxidase, dopamine hydroxylase, ceruloplasmin or it is provide the activation these enzymes as a cofactor (Wedekind et al. 1992; İpek et al. 2003). It is one of the essential trace minerals for healthy growth, development and metabolic functions of living organism (Kozlowski et al. 2018).

Inorganic sources such as sulphate, which is a cheap source of Cu, are used in poultry diets. However, organic sources of Cu, such as amino acids or complex chelates, are absorbed more effectively from inorganic salts in the intestines (Wedekind et al. 1992; Aoyagi and Baker 1993). Therefore, as in other elements, the inorganic form of Cu is low in absorption and accumulates as a contaminant in soil and ground water because it is excreted with faces. Since the absorption of organic Cu sources from the intestine is higher than inorganic sources, both the amount added to the diet and the amount excreted with the faces are less compared with inorganic sources (Bao et al. 2007; Gupta and Charles 1999). Therefore, the use of organic sources of Cu is important not only for poultry nutrition, but also for the environment.

Copper requirement of quails was reported as 5 mg/kg by NRC (1994). There were studies reported that the supplementation of high levels of Cu to layer diets was improved (Abaza et al. 2009; Olgun et al. 2013; Kaya et al. 2018) or deteriorated (Mendonca et al. 1999; Tekeli et al. 2005) performance and eggshell quality in birds. Kaya et al. (2018) showed that the addition of 200, 250 and 300 mg/kg levels of Cu to the diet decreased egg weight and feed intake in laying hens but increased eggshell resistance. Olgun and Aygun (2017) stated that the addition of Cu (150 or 300 mg/kg) to the diet improved the performance parameters of laying hens and decreased the eggshell weight. However, the Cu levels (from 50 to 800 mg/kg) in these studies are quite high. In addition, the number of studies investigating the effect of addition of low levels Cu is also very limited, especially the effects in quails or on haematological parameters.

In the light of these findings, the aim of this study was to investigate the effects of supplementation different levels organic Cu to diets on performance, egg quality parameters and haematological in quails.

Material and Method

In this study, a total of 80 female Japanese quails at the age of 22 weeks have been randomly distributed among four treatment groups and has lasted 10 weeks. In each treatment group, there have been four replicates, each with five quail. For 10 weeks, the quails were fed four experimental diets containing four levels (0, 5, 10 and 20 mg/kg) of Cu as Cu propionate. The experimental diets were balanced to meet or exceed the nutrient requirements of the Japanese quail (NRC 1994). The control diet and its calculated nutrient contents are shown in Table 1. During the experiment, water and feed were given as ad libitum.

Performance Parameters

Body weight change (BWC), was obtained by group weighing of the quails in the beginning and final of experiment. Feed intake (FI) was calculated at the final of research. Egg production (EP) was recorded daily. Egg weight (EW) was found out by weighing all eggs collected at last two days of research. Egg mass was calculated with EM= (EP (%) × EW)/100 formula. Feed conversion ratio (FCR) was obtained from FCR= FI (g/feed/quail)/EM (g/egg/quail).

Egg Quality Parameters

Related measurements about of eggshell quality (membrane eggshell weight (%), membrane eggshell thickness and eggshell strength) and Haugh unit parameters were made on the all eggs collected at last two days of treatment. Length and diameter of each egg were determined by digital calliper. Egg shape index was calculated with egg diameter/egg length × 100 formula by using these parameters. Eggshell strength was measured by applying supported systematic pressure to blunt of the eggs (Egg Force Reader, Orka Food Technology, Israel). Subsequently, albumin height has been determined with digital height gauge. Haugh unit was calculated as follows: Haugh unit = 100 × log (albumin height + 7.57-1.7 × $EW^{0.37}$) (Haugh 1937). Membrane eggshell weight rate was determined by using eggshell weight (g)/egg weight (g) × 100 formula. The membrane eggshell thickness was calculated from the values obtained with digital calliper from three sections of the eggs. The egg quality analyses were completed within 24 hours after eggs were collected.

Haematological Analysis

At the end of the study, the bloods were taken into heparinised tubes by entering with syringe to the heart of randomly selected one quail each replicate (four quail per treatment group) for haematological analysis. The bloods haematological analysis were made by auto-analyser according to Campbell (1988).

Statistical Analysis

At the end of the research, the variance analyses have been applied to all variables obtained from the trial groups (Minitab 2000), and the differences between means of the groups were determined by the Tukey multiple comparison test.

Results and Discussion

The effect of adding different levels of organic Cu to the diets on performance parameters in laying quails are demonstrated at Table 2. There have no significant differences among treatment groups for EP, EW, EM and FCR (P>0.05). In this study, BWC was significantly reduced by 20 mg/kg Cu supplementation with compared other groups (P<0.01). While the highest BWC was obtained at 5 mg/kg, this difference has not statistically significant compared to the 0 or 10 mg/kg Cu levels groups. At the final of experiment, the lowest FI shown in quails fed with diet added 10 mg/kg organic Cu, and this statistically significant compared to other groups (P<0.05).

There have been studies, which investigated the effect of supplementation different levels Cu to diets on performance parameters. Contrary to the results obtained in the current research, in some studies, it was reported that the addition of Cu to diets of layers has not affect for BWC and FI (Ankari et al. 1998; Pesti and Bakalli 1998; Balevi and Coskun 2004; Azman and Yılmaz 2005; Olgun et al. 2013).

Table 1. Control diet and its calculated nutrient contents

Ingredients	%	Nutrient contents	Value
Corn	54.20	Metabolisable energy, kcal ME/kg	2902
Soybean meal	27.00	Crude protein, %	20.09
Sunflowers meal	7.00	Calcium, %	2.51
Vegetable oil	4.30	Available phosphorus, %	0.35
Limestone	5.60	Lysine, %	1.00
Dicalcium phosphate	1.15	Methionine, %	0.45
Salt	0.35	Cystine, %	0.37
Premix[1]	0.25	Methionine+cystine, %	0.82
DL methionine	0.15	Copper, mg/kg	35.95
Total	100.00		

[1]Premix is provide that per 1 kg of diet; manganese: 80 mg, iron: 60 mg, copper: 5 mg; iodine, 1 mg, selenium: 0.15 mg, Vitamin A:8.800 IU, Vitamin D_3: 2.200 IU, Vitamin E: 11 mg, Nicotine acid: 44 mg, Cal-D-Pan: 8.8 mg, Riboflavin: 4.4 mg, Thiamine: 2.5 mg, Vitamin B_{12}: 6.6 mg, Folic acid: 1 mg, Biotin: 0.11 mg, Choline: 220 mg.

Table 2. Effects of supplementation different levels organic copper to diets on performance parameters in Japanese quails

Parameters	Organic Cu Levels				SEM*	P values
	0 mg/kg	5 mg/kg	10 mg/kg	20 mg/kg		
BWC, g	11.17^{A}	22.08^{A}	11.83^{A}	-8.00^{B}	3.564	0.001
EP, %	89.42	90.12	91.01	88.63	1.222	0.614
EW, g	13.20	13.39	12.63	12.96	0.255	0.287
EM, g/d/quail	11.80	12.06	11.49	11.49	0.270	0.435
FI, g/d/quail	35.73^{a}	35.52^{a}	33.40^{b}	35.71^{a}	0.462	0.013
FCR, FI/EM	3.03	2.95	2.91	3.12	0.059	0.134

BWC: Body Weight Change, EP: Egg Production, EW: Egg Weight, EM: Egg Mass, FI: Feed Intake, FCR: Feed Conversion Ratio.*Standard error means, ^{AB}Values bearing different superscript in rows are statistically different; P<0.01., ^{ab}Values bearing different superscript in rows are statistically different; P<0.05.

Table 3. Effects of supplementation different levels organic copper to diets on egg quality parameters in Japanese quails

Parameters	Organic Cu Levels				SEM*	P values
	0 mg/kg	5 mg/kg	10 mg/kg	20 mg/kg		
Damaged Eggs, %	0.00	0.68	0.00	0.30	0.111	0.058
Egg Shape Index	76.83	79.68	77.39	78.01	0.996	0.397
Eggshell Breaking Strength, kg	1.57^{A}	1.62^{A}	1.51^{AB}	1.37^{B}	0.041	0.010
Eggshell Weight, % EW	7.90^{A}	7.84^{AB}	8.19^{A}	7.34^{B}	0.111	0.003
Eggshell Thickness, µm	194.00^{B}	202.75^{AB}	202.25^{AB}	208.25^{A}	1.838	0.010
Haugh Unit	76.15	75.56	71.07	73.96	1.488	0.190

* Standard error means, ^{AB}Values bearing different superscript in rows are statistically different; P<0.01.

Table 4. Effects of supplementation different levels organic copper to diets on some blood parameters in Japanese quails

Parameters	Organic Cu Levels				SEM*	P values
	0 mg/kg	5 mg/kg	10 mg/kg	20 mg/kg		
WBC, 10^3/µl	15.05	15.57	11.82	15.50	1.303	0.307
NEU, 10^3/µl	0.76^{B}	1.01^{B}	1.67^{A}	0.91^{B}	0.108	0.001
LYM, 10^3/µl	15.61	14.47	11.74	10.55	1.746	0.334
RBC, 10^6/µl	3.19	3.18	3.39	2.65	0.213	0.207
HGB, g/dL	17.73	17.63	17.25	16.23	0.495	0.313
HCT, %	47.00	45.97	45.29	40.80	1.588	0.145
MCV, µm^3	148.00	145.33	146.81	154.00	2.088	0.107
MCH, pg	55.77^{B}	56.00^{B}	54.93^{B}	61.33^{A}	1.006	0.007
MCHC, g/dL	37.73	38.60	38.73	39.83	0.440	0.086
RDW, %	10.23	10.30	10.34	11.23	0.376	0.335
PLT, 10^3/µl	7.69	10.67	5.51	12.62	2.259	0.247
HGB/LYM	1.15	1.29	1.48	2.36	0.320	0.362

WBC: White Blood Cell, NEU: Neutrophil, LYM: Lymphocyte, RBC: Red Blood Cell, HGB: Haemoglobin, HCT: Haematocrit, MCV: Erythrocyte Volume, MCH: Mean Corpuscular Haemoglobin, MCHC: Corpuscular Haemoglobin Concentration, RDW: Red Blood Cell Distribution Width, PLT: Thrombocyte, HGB/LYM: Haemoglobin/Lymphocyte Ratio., * Standard error means ^{AB} Values bearing different superscript in rows are statistically different; P<0.01.

On the other hand, Kocaoğlu Güçlü et al. (2008) stated that the addition of 150 and 300 mg/kg levels of Cu as Cu-proteinate to the diet increased the EP without affecting body weight and FI in laying hens. Similarly, Mendonca et al. (1999) investigated the effects of supplementation high levels (400, 600 and 800 mg/kg) of Cu to the diet. It was reported that the FI was not affected with the addition of 400 mg/kg Cu in the diets. However, it decreased as the level of Cu increased. In addition to these, Idowu et al. (2006); Kaya et al. (2009) stated that the FI was decreased with the supplementation of Cu to the layer diets. In the current study, this decrease in FI of the 10 mg/kg Cu group improved FCR numerically but is statistically insignificant.

The effect of supplementation different levels Cu to diets on egg quality parameters has been given at Table 3. The results of the study showed that the treatments on the damaged eggs, egg shape index and Haugh unit parameters have not statistically significant (P>0.05). At the group supplemented 20 mg/kg Cu, eggshell breaking strength and eggshell weight were significantly decreased (P<0.01). While the highest eggshell breaking strength found at 5 mg/kg level, the highest eggshell weight was obtained from the group added 10 mg/kg Cu (P<0.01). On the other hand, eggshell thickness parameter has been significantly increased at the 20 mg/kg Cu unlike eggshell breaking strength and eggshell weight, and this raise has been found statistically significant compared to other Cu levels (P<0.01). Also, eggshell thickness was statistically diminished at the control group compared to 20 mg/kg level Cu (P<0.01).

Mendonca et al. (1999) and Tekeli et al. (2005) reported that the decreased of eggshell breaking strength and eggshell weight with supplementation from 75 to 800 mg/kg Cu to diets. These study results agree with the current study results. On the contrary, there are also research which stated Kaya et al. (2009) and Olgun et al. (2012) found out that the addition of Cu to the diets improved eggshell strength. In addition to, Idowu et al.

(2006) demonstrated that the supplementation of Cu to layer diets was not affected. Brodacki et al. (2018) stated that the addition of 30 mg/L Cu-lysine as an organic source to drinking water increased the eggshell weight without affecting the eggshell resistance and thickness.

The effect of adding different levels Cu to diets on some blood parameters is demonstrated at Table 4. According to these results, there were no significant differences among treatment groups in terms of white blood cell (WBC), lymphocyte (LYM), red blood cell (RBC), haemoglobin (HGB), haematocrit (HCT), erythrocyte volume (MCV), corpuscular haemoglobin concentration (MCHC), red blood cell distribution width (RDW), thrombocyte (PLT) parameters and haemoglobin/lymphocyte ratio (HGB/LYM) ($P>0.05$). However, neutrophil (NEU) has significantly risen with 10 mg/kg level Cu compared to other treatment groups ($P<0.01$). The lowest NEU obtained from the control group but this different has insignificant compared with 5 mg/kg and 20 mg/kg levels. In addition, mean corpuscular haemoglobin (MCH) was significantly increased at the 20 mg/kg level ($P<0.01$) with compared the other groups. The result agree with the findings of Sharma et al. (2009), who stated that orally administered in a dose of 2 mg/day Cu in male chicks increased whole blood, erythrocytes and MCH, but did not affect other blood parameters. In addition, İpek et al. (2003) reported that the supplementation of 50 and 150 mg/kg levels of Cu to the laying quail diets has not affect some haematological parameters. El-Ghalid et al. (2019) showed that the addition of 50 and 100 mg/kg of organic Cu (Cu-methionine or Cu-glycine) to the diet significantly increased blood haematological (RBC, HGB, WBC and LYM) parameters in broilers compared to the control or inorganic Cu supplement groups. The reason for the decrease in body weight change, eggshell resistance and eggshell weight may be the high MHC caused by Cu, and other parameters may also be thought to decrease in time at high Cu levels or longer trial periods.

There are differences among the results of the studies examined the effects of sources and levels of Cu on performance and eggshell quality in layer birds. Therefore, further studies have been required the more long-termed and detailed with different sources and levels of Cu to understand effects on the performance and eggshell parameters in poultry.

The addition of 20 mg/kg (total 56 mg/kg Cu in the diet) organic Cu to the diet negatively affected the eggshell quality and some blood parameters of layer quails. According to the results obtained from the trial, it can be said that the most suitable Cu level in laying quail diets is 10 mg/kg.

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