Effect of Zinc Supplementation in the Diet on Sikumbang Janti Female Duck Performance, Carcass, Digestive Organs, and Intestinal Morphology

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ABSTRAK

Rusli RK, Amizar R, Zurmiati, Ananda, Darmawan A, Subekti K, Khalil. Pengaruh suplementasi zinc dalam pakan terhadap performa, karkas, organ pencernaan, dan morfologi intestinal bebek Sikumbang Jati betina. JITV 28(2):136-142. DOI:http://dx.doi.org/10.14334/jitv.v28.i2.3209.

Penelitian bertujuan untuk mengevaluasi pengaruh suplementasi Zn pada ransum itik Sikumbang Janti betina terhadap performa, karkas, organ pencernaan, dan morfologi usus. Penelitian menggunakan 96 ekor itik betina umur 8 minggu dipakai sebagai materi percobaan. Penelitian ini menggunakan rancangan acak lengkap dengan empat perlakuan (0, 30, 60, dan 90 mg Zn/kg), masing-masing perlakuan diulang sebanyak empat kali. Parameter yang diukur performa, karkas, organ pencernaan, dan morfologi usus. Hasil penelitian menunjukkan bahwa suplementasi Zn berpengaruh nyata (P<0,05) meningkatkan bobot badan, pertambahan bobot badan, efisiensi penggunaan ransum, bobot karkas, menurunkan lemak perut, dan meningkatkan ukuran morfologi usus, namun tidak mempengaruhi (P>0,05) konsumsi pakan, persentase karkas, dan ukuran organ pencernaan. Sebagai kesimpulannya, suplementasi 60 mg Zn/kg dalam ransum dapat memperbaiki performa itik Sikumbang Janti betina yang dipelihara umur 8-16 minggu.

Kata Kunci: Suplementasi Zn, Performa Pertumbuhan, Morfologi Usus, Itik Lokal, Organ Dalam

ABSTRACT

Rusli RK, Amizar R, Zurmiati, Ananda, Darmawan A, Subekti K, Khalil. Effect of zinc supplementation in the diet on Sikumbang Janti female duck performance, carcass, digestive organs, and intestinal morphology. JITV 28(2):136-142. DOI:http://dx.doi.org/10.14334/jitv.v28.i2.3209.

The research aimed to evaluate the effect of Zn supplementation in diet of Sikumbang Janti female duck on its performance, carcass, digestive organs, and intestinal morphology. The study used 96 female ducks aged 8 weeks. This research used a completely randomized design with four treatments (0, 30, 60, and 90 mg Zn/kg), each treatment was repeated four times. Performance, carcass, digestive organs, and intestinal morphology were observed. The results showed that Zn supplementation significantly (P<0.05) affected body weight, body weight gain, feed conversion ratio, carcass weight, abdominal fat, and intestinal morphology, but it did not affect (P>0.05) feed consumption, carcass percentage, and digestive organs. In conclusion, supplementation of 60 mg Zn/kg in the diet improved performance, intestinal morphology, and the health of visceral of Sikumbang Janti female ducks aged 8 to 16 weeks.

Key words: Dietary Zn Supplementation, Growth Performance, Intestinal Morphology, Local Duck, Visceral

INTRODUCTION

Ducks are one of the potential egg and meat-producing types of poultry after chicken commodities. In the West Sumatra province, the population of ducks in 2021 was around 1,185,955 birds (Badan Pusat Statistik 2022), spread throughout rural and urban areas. One of the potential indigenous ducks in Payakumbuh City, West Sumatra, is Sikumbang Janti duck.

However, the development of the Sikumbang Janti duck population in West Sumatra faces various obstacles, including the dominance of smallholder duck farms with extensive systems and low-quality feed. The extensive duck-rearing system is heavily dependent on the availability of quality feed. A lack of quality feeds will cause performance to decrease, as well as an increase in disease and mortality rates. In addition, to feed quality, productivity and mortality are closely related to environmental conditions (e.g., high relative humidity and temperature). This condition must be overcome immediately in terms of developing the Sikumbang Janti duck population. Moreover, information on the status of Zn mineral in common feed duck rise in West Sumatera is not available. Therefore a study to determine the Zinc level required by Sikumbang-janti duck is important. One of the efforts that can be conducted is supplementing zinc (Zn) minerals in the ration to fulfill the trace mineral requirement and increase feed quality

Zink (Zn) is a micro-mineral that plays various processes, i.e., gene regulation, cell proliferation, cofactor enzyme, immune responses, defense against oxidative stress (Maret 2013; Marreiro et al.. 2017; Hidayat et al.. 2020), growth (Liu et al.. 2018), intestine health, eqq quality (Fan et al.. 2022) and reproduction (Chand et al.. 2014). Previous research found that consuming Zn can enhance the productivity and immune systems of Longyan ducks, Magelang duck, and Pekin ducks (Attia et al.. 2013; Darmawan et al.. 2013; Zhang et al.. 2021). However, there has been no report on the supplementation of Zn in the diet of Sikumbang Janti female ducks. Therefore, this study aimed to evaluate the effect of Zn supplementation in diet of Sikumbang Janti female duck on its performance, carcass, digestive organs, and intestinal morphology.

MATERIALS AND METHODS

Animal, design, and diet

This research was approved for experimental animals by the Research Ethics Committee of the Faculty of Medicine Universitas Andalas (No. 31/UN.16.2/KEP-FK/2023). This research used 96 Sikumbang Janti female ducks aged 8 weeks (average weight of 752.41±81.99 g/bird). The Sikumbang Janti female ducks were acquired from a commercial farmer from Payakumbuh City, West Sumatra, Indonesia. The observation was conducted for 8 weeks and used a completely randomized design of 4 treatments with 4 replicates (6 ducks/replicate). Ducks were distributed at random into cages (1.5 x 1.5 m). A drinker tube and a bucket feeder were installed in the cage to supply feed and water. The Zn used was 75% ZnO (Zn-O-India). The ration was prepared based on Sinurat, (2000), with a 17% crude protein, and 2700 metabolizable energy. Table 1 lists the treatment diet's ingredients and composition. The treatments design are presented in Table 2.

Table 1. Feed ingredient and nutrient content of control diet

Ingredients	%
Corn	55.00
Rice bran	15.40
Soybean meal	18.00
Fish meal	8.50
$CaCO_3$	2.50
Top mix[1]	0.50
Dl-Methionine[2]	0.10
Total	100.00
Metabolizable Energy, (Kcal/kg)	2744.55
Crude Protein, (%)	17.36
Crude Fibre, (%)	3.63
Crude Fat, (%)	1.58
Available Phosphorus, (%)	0.59
Methionine, (%)	0.54
Lysine, (%)	1.22
Zn, (mg/kg)	29.59

[1]Provides per kilogram of diet = Vitamin A 12.000 IU; Vitamin D3 2000000 IU; Vitamin E 8000 IU; Vitamin K_3 2000 mg; Vitamin B_1 2000; Vitamin B_2 5000 mg; Vitamin B_6 500 mg; Vitamin $B1_2$ 1.200 µg; Vitamin C 25.000 mg; Ca-D-Pathotenate 6.000 mg; Niacin 40000; Cholin Chloride 10000 mg; Lysine 30.000 mg; Methionine 30000 mg; Manganese 120000 mg; Iron 20000 mg; Zinc 100 mg; Iodine 200 mg; Cobalt 200 mg; Copper 4.000 mg; Santoquin 10000 mg; Growth promoter 1300000, [2]Dl-Methionine (Shandong Nhu Amino Acid Co. LTD)

Table 2. Zinc supplementation experimental diets

Treatments	Description	Total Zn in the diet (mg/kg)
Z0	Control feed	29.59
Z1	Z0 + 30 mg Zn/kg	59.59
Z2	Z0 + 60 mg Zn/kg	89.59
Z3	Z0 + 90 mg Zn/kg	119.59

Variables observed

Feed consumption (FC), body weight gain (BWG), and feed conversion ratio (FCR) were recorded weekly at each replication. A digital weighing scale measured feed and body weight (BW). Carcass, and digestive organs followed the procedure described by Mutia et al. (2017), at the end of the research (16 weeks), Sikumbang Janti female ducks (one duck per repetition) were slaughtered to obtain carcass, digestive organs. The observed variables included carcass, abdominal fat, proventriculus, ventriculus, pancreas, liver, spleen, heart, bile, small intestine, ceca, and colon. A digital balance (Osuka-HWH®, Japan). Intestinal morphology. Intestinal sample preparation was carried out by following the methods of Chiou et al. (1999). the ileum intestinal sample was cut 2 cm long and then soaked in 10% formalin to make preparations. Villus wide (VW), villus height (VH) and crypt depth (CD) were determined using an Olympus CX 21 microscope with 4x magnification. After the histology of the intestine was found as expected, a photo was taken. Minimum measurements were made three times per slide made for each parameter. additionally, ImageJ Ink software made Villus wide, villus height, and crypt depth measurements on a computer. A computer determined the µm size standard in advance where the magnification value used was in units of length (µm). The µm unit number obtained was then used as a standard in calculating the villus wide, villus height, and crypt depth on a monitor screen.

Data analysis

The data obtained were analyzed by analysis of variance, and differences between treatments followed Duncan’s multiple range test. The means data were provided with SEM and P values.

RESULTS AND DISCUSSION

Performance

The impact of Zn supplementation on the performance of Sikumbang Janti female ducks (Table 3) showed that Zn supplementation at 30 mg/kg significantly ($P<0.05$) decreased FCR while increasing BW and BWG compared to the control group. The effects of zinc supplementation at 30 mg/kg on FCR, BW, and BWG were equivalent to those of supplements at 60 and 90 mg/kg. During the trial, adding Zn did not impact FC ($P>0.05$).

The production performance (BW, BWG, and FCR) of the Sikumbang Janti female duck, was significantly increased by an increase in the Zn level. In this study, the average value of total Zn consumed for Z0, Z1, Z2, and Z3 was 177.46 mg/bird (29.59 mg/kg), 360.35 mg/bird (59.59 mg/kg), 536.34 mg/bird (89.59 mg/kg), and 713.62 mg/bird (119.59 mg/kg), respectively. These results were supported by previous studies showing that the mineral Zn can meet the needs of trace minerals that can support production performance, reproduction, immunity, and the normal development of feathers and bones (Abd El-Hack et al. 2017; Hidayat et al. 2020; Jafari et al. 2021; Hidayat et al. 2021; Zhu et al. 2022). This was also in line with other studies which reported that Zn supplementation on the Pekin duck diet increased BW and WG, decreased FCR, and did not affect FC (Attia et al. 2013; Wu et al. 2019; Xie et al. 2021). However, Attia et al. (2013) reported that adding 120 ppm Zn to the white Pekin duck diet decreased BWG.

Zn is an essential element of digestive enzymes and other enzymes such as hydrolases, oxidoreductases, transferases, lyases, ligases, and isomerases (Park et al. 2004). Therefore, Zn in feed aids in the digestion and metabolic processes of proteins, lipids, and carbohydrates into substrates that are easily absorbed in the intestine and stored in the tissue (Azad et al. 2020). According to Azad et al. (2020), the addition of 50 mg Zn to the broiler's diet is sufficient for proper growth up to 28 days of age. Similarly, adding zinc to poultry feed increases their ability to produce antibodies. Thymulin, the thymus hormone, regulates T lymphocytes by promoting T lymphocyte maturation and activating lymphocytes. Zn is a crucial component of this hormone (Weyh et al. 2022). Zn supplementation triggers the development of lymphocytes which can reduce stress in poultry as indicated by a decrease in the ratio of heterophils/lymphocytes (Ebrahimzadeh et al. 2012). Furthermore, Zn supplementation can also improve antioxidant status. The Cu Zn-superoxide dismutase reduces free radicals by acting as a cofactor for Zn (Yu et al. 2020). Additionally, 45 mg/kg Zn sulphate in laying hens diet stimulates the formation of metallothionein, which efficiently scavenges hydroxyl radicals (Niknia et al. 2022). The positive impact of dietary Zn on BWG and FCR may also be due to the increased intestinal absorptive surface area as indicated by the greater height and villi width in this research. The beneficial impact of Zn can increase the availability of nutrients and improve health, both of which lead to an increase in the ducks' BW.

Carcass

Zn supplementation effect on the carcass of the Sikumbang female Janti duck is in Table 4. Zn supplementation at 60 mg/kg (Z2 treatment) significantly (P<0.05) improved carcass weight in contrast to the control (Z0 treatment). Zn supplementation at 60 mg/kg significantly (P<0.05) reduced abdominal fat in contrast to Z0, and Z1 treatment. However, it was no different from the Z3 group (90 mg/kg). Carcass percentage was not impacted (P>0.05) by supplementation of Zn in the diet. However, the treatments did not show a significant effect (P>0.05) on the percentage of BW.

This research showed that the weight of the carcass increased with Zn supplementation in Sikumbang Janti female ducks. These results were consistent with research on turkey, which showed that adding 120-140 mg Zn/kg to the diet increased growth performance and carcass yield (Flores et al. 2021). This was due to the higher body weight of the ducks and the lower percentage of abdominal fat yielded by Zn supplementation treatment. Carcass weight is strongly influenced by live weight which in higher live weight results in greater carcass weight and *vice versa*.

This research's percentage of abdominal fat was reduced as Zn supplementation in the diet increased. According to Attia et al. (2013) and Hidayat et al.. (2020), dietary Zn supplementation decreased the proportion of abdominal fat compared to without Zn. According to other studies, variations in species and dietary Zn concentration could account for the lack of a rise in abdominal fat. Supplementation of 60 mg Zn/kg in a broilers diet could reduce abdominal fat by modulating lipogenic enzyme activity and gene expression, promoting hepatic fat metabolism, and stimulating lipid synthesis (Liu et al. 2015).

Digestive organs

Zn supplementation effect on the digestive organs of Sikumbang Janti female duck is shown in Table 4. Supplementation of Zn did not significantly affect (P>0.05) the digestive organs. These findings align with

Table 3. Effect of Zn supplementation in diets on productive performance and Zn consumption of Sikumbang Janti female duck aged from 8 to 16 weeks

Variables	Treatments				SEM	P-value
	Z0[1)]	Z1	Z2	Z3		
FC[2)] (g/bird)	5997.38	6047.09	5986.62	5967.22	26.86	0.79
BW (g/bird)	1314.[25a3)]	1417.62[b]	1420.83[b]	1400.16[ab]	17.74	0.09
BWG (g/bird)	599.08[a]	668.29[b]	668.46[b]	650.33[b]	15.83	0.02
FCR	10.81[a]	9.08[b]	8.99[b]	9.20[b]	0.26	0.02
Zn consumption (mg/bird)	177.46	360.35	536.34	713.62		

[1)]Z0 (Control diet), Z1 (Control diet+30 mg Zn/kg), Z2 (Control diet+60 mg Zn/kg), and Z3 (Control diet+90 mg Zn/kg), [2)]FC (feed consumption), BW (body weight), BWG (body weight gain), FCR (feed Conversion ratio), [3)]Means with different superscripts in the same row differ significantly (P<0.05)

Table 4. Effect of Zn supplementation in diet on carcass of Sikumbang Janti female duck aged from 8 to 16 weeks.

Variables	Treatments				SEM	P-value
	Z0[1)]	Z1	Z2	Z3		
Carcass weight (g)	710.25[a2)]	772.00 [ab]	800.250[b]	753.75[ab]	13.23	0.08
Carcass (%)	53.62	54.86	55.20	53.52	0.63	0.75
Abdominal fat (%)	1.58[a]	1.16[b]	0.86[c]	0.86[c]	0.08	0.00

[1)]Z0 (Control diet), Z1 (Control diet+30 mg Zn/kg), Z2 (Control diet+60 mg Zn/kg), and Z3 (Control diet+90 mg Zn/kg). [2)]Means with different superscripts in the same row differ significantly (P<0.05)

Table 5. Effect of Zn supplementation in diet on digestive and visceral organs of Sikumbang Janti female duck aged from 8 to 16 weeks

Variables	Treatments				SEM	P-value
	Z0[1)]	Z1	Z2	Z3		
Proventriculus (%)	0.42	0.41	0.37	0.38	0.01	0.48
Ventriculus (%)	3.14	2.92	2.96	2.88	0.08	0.71
Pancreas (%)	0.29	0.47	0.27	0.26	0.05	0.34
Liver (%)	2.61	2.16	2.45	2.38	0.09	0.40
Heart (%)	0.60	0.58	0.62	0.56	0.02	0.76
Spleen (%)	0.11	0.10	0.09	0.11	0.01	0.52
Bile (%)	0.12	0.12	0.10	0.10	0.01	0.49
Small Intestine (%)	2.92	2.92	2.99	3.39	0.11	0.44
Duodenum (cm)	26.33	27.50	27.66	28.87	0.47	0.32
Jejunum (cm)	69.66	72.33	72.50	70.00	1.07	0.73
Ileum (cm)	59.00	59.75	64.00	62.50	1.00	0.26
Ceca (%)	0.34	0.31	0.30	0.31	0.01	0.54
Colon (%)	0.28	0.29	0.24	0.29	0.01	0.17

[1)]Z0 (Control diet), Z1 (Control diet+30 mg Zn/kg), Z2 (Control diet+60 mg Zn/kg), and Z3 (Control diet+90 mg Zn/kg)

Table 6. Effect of Zn supplementation in diet on villus height (VH), villus width (VW), crypt depth (CD) and the ratio of villus height to crypt depth of Sikumbang Janti female duck aged from 8 to 16 weeks

Variables	Treatments				SEM	P-value
	Z0[1)]	Z1	Z2	Z3		
VH (mm)	0.69[b2)]	0.72[c]	0.79[d]	0.64[a]	0.01	0.001
VW (mm)	0.16[a]	0.19[a]	0.24[b]	0.17[a]	0.01	0.001
CD (mm)	0.24[a]	0.20[b]	0.17[c]	0.18[bc]	0.01	0.001
VH/CD ratio	2.86[a]	3.47[b]	4.67[c]	3.43[b]	0.08	0.001

[1)]Z0 (Control diet), Z1 (Control diet + 30 mg Zn/kg), Z2 (Control diet + 60 mg Zn/kg), and Z3 (Control diet + 90 mg Zn/kg). [2)]means with different superscripts in the same row differ significantly ($P<0.01$)

other earlier studies that found Zn supplements, both organic and inorganic, up to 120 mg/kg in the feed had no adverse effects on the visceral and digestive organ size (Attia et al.. 2013). Also, there was no difference in the percentages of pancreas, spleen, liver and heart when the ducks were fed with 30 mg/kg Zn oxide, but it increased the percentage of gizzard (Attia et al.. 2019). According to the previous study, adding 30-120 mg/kg (Ahmadi, 2013) and 30-160 mg/kg (Hidayat et al.. 2020) ZnO nanoparticles to broiler feed significantly affected liver weight. Several factors may explain the different effects of dietary Zn on internal organs, such as Zn concentration and source or type, rearing management, age, or environmental conditions.

Intestinal morphology

The impact of Zn Supplementation on villus height (VH), width height (WH), crypt depth (CD), and villus height/crypt depth (VH/DH) of Sikumbang Janti female duck is presented in Table 6. The Z2 treatment (60 mg Zn/kg) had the most significant ($P<0.01$) VH, VW, CD, VH/CD. These results align with the past result of Wu et al.. (2019) and Xie et al. (2021) that Zn supplementation improved the morphology of the small intestine as indicated by a decrease in the ratio of VH/CD, and an increase in duck VH.

In this research, an increase in VH and VW in the small intestine of Sikumbang Janti female ducks in Zn supplemented can be linked to the increased proliferation of crypt cell so that led to an increase in the digestive process and absorption due to an expansion of the nutrient absorption area, as indicated by better body weight gain and feed conversion efficiency. Our VH, CD, and VH/ CD ratio result were similar to those of Khajeh Bami et al.. (2018) who reported supplementation of 50 Zn-nano in a broiler diet were significantly better than a fed diet with 25 Zn-nano.

Similarly, Shah et al.. (2019) said that Zn supplemented 60 mg Zn/kg in a broiler diet improved VH, CD, and VH/CD ratio.

The digestion capacity and absorption of nutrients depend on the intestine's morphological conditions, especially the villi's surface area (Jia et al.. 2010). The elongated and larger villi show a greater surface area for nutrient absorption (Sacakli et al.. 2023). A smaller CD improved the intestine's capacity to absorb nutrients, A greater VH:CD ratio indicated enhanced digestion and absorption of nutrients in the small intestine (Shang et al.. 2020). Small intestines serve as a vital barrier against the introduction of toxic materials into the body, in addition to serving as a means of digestion and nutritional absorption.

Based on the results of this study, the use of Zn can be applied by farmers and the industry. The use of Zn minerals in the ration is small and low price, but the impact can improve performance so that the economic value also increases.

CONCLUSION

Dietary Zn at 60 mg/kg in Sikumbang Janti's diet increased BW, BWG and carcass weight and decreased FCR and abdominal fat without increasing feed intake, and the size of digestive organs. Supplementation of 60 mg Zn/kg) improved the greatest intestinal health, as indicated by an increase in VH, VW, CD, and VH/CD ratio.

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