



Effects of Zinc Supplementation on Mineral Bioavailability, Blood Constituents, and Malondialdehyde Levels in Sikumbang Janti Ducks

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Abstract | The study aimed to evaluate the effect of Zn supplementation in the diet of female Sikumbang Janti ducks on mineral availability, blood constituents, and blood plasma malondialdehyde. This study used 96 female ducks aged eight weeks and was employed in a completely randomized with four treatments (0, 30, 60, and 90 mg Zn/kg) and four replicates. Parameters measured were mineral availability, blood constituents, and blood plasma malondialdehyde. The results showed that Zn supplementation at 90 mg/kg significantly ($P < 0.05$) increased the weight of mineral availability i.e. Zn (2.62 $\mu\text{g/ml}$), Ca (12.73 $\mu\text{g/ml}$), P (5.27 $\mu\text{g/ml}$), and decreased blood plasma malondialdehyde (0.97 $\mu\text{g/ml}$). Supplementation Zn at 60 mg/kg significantly ($P < 0.05$) increased blood constituents (except glucose content). In conclusion, supplementation of 90 mg Zn /kg in the diet of Sikumbang Janti ducks enhances mineral availability (Ca, P, Zn) and total protein levels, and reduces triglyceride and malondialdehyde content in blood plasma.

Keywords | Blood constituents, Duck, Health, Malondialdehyde, Mineral availability, Zinc

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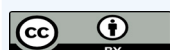
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INTRODUCTION

Sikumbang Janti ducks represent local germplasm from Payakumbuh, West Sumatra, which has great potential (especially as laying ducks) for further development. The Sikumbang Janti duck population in West Sumatra faces many obstacles, especially the small-scale duck farming system that relies on extensive rearing patterns and low feed quality. Substandard feed quality leads to reduced performance, increased disease prevalence and mortality. In

addition to feed quality, production and mortality are also greatly affected by environmental factors, including high humidity and temperature. These challenges require immediate attention to facilitate the growth of the Janti Sikumbang duck population.

Zinc (Zn) is one of the essential microminerals that is very important for poultry. Zn functions as a structural and catalytic component in various metalloenzymes, thus playing an important role in growth, development, reproduction,

and metabolic activities in poultry and mammalian species (Hidayat *et al.*, 2024; Megha *et al.*, 2024; Zhang *et al.*, 2023). Several studies have shown that Zn supplementation in feed is essential for optimizing livestock health and productivity, including in sikumbang janti duck (Rusli *et al.*, 2023a; Rusli *et al.*, 2023b), geese (Fan *et al.*, 2022), broilers (Ogbuewu and Mbajorgu, 2023), layers (Al-Obaidi *et al.*, 2022; Megha *et al.*, 2024), and quail (Pontes *et al.*, 2024).

Zn deficiency can result in metabolic disorders and decreased productivity, hence Zn supplementation is considered as one of the effective solutions in improving poultry performance. In addition, Zn supplementation is also thought to play a role in improving hematological parameters in poultry. Hematology is an important indicator in assessing the health status of poultry, including blood conditions that reflect normal physiological functions. Some previous studies have shown that Zn can affect blood lipid profiles (Kim and Kang *et al.*, 2022). On the other hand, Oxidative stress represents a significant challenge to poultry health, marked by an increase in malondialdehyde (MDA) levels, a byproduct of lipid peroxidation. MDA is widely recognized as a biomarker of cellular damage resulting from free radical exposure; elevated MDA concentrations are indicative of substantial oxidative stress (Cordiano *et al.*, 2023). Zinc (Zn) plays a crucial role as an antioxidant by enhancing the activity of the enzyme superoxide dismutase (SOD), which mitigates oxidative damage by reducing MDA levels. Although there has been research related to the use of zinc in ducks, until now there has been no research on the effect on Zn mineral availability and MDA content in the blood. Therefore, this study aims to investigate the effects of Zn supplementation on mineral bioavailability, blood health markers, and MDA levels in Sikumbang Janti ducks, thereby advancing our understanding of Zn's role in supporting the health and performance of poultry.

MATERIALS AND METHODS

ETHICAL CLEARANCE

The rearing and blood collection of Sikumbang Janti ducks were carried out properly according to the guidelines of the Ethics Committee of the Faculty of Medicine, Andalas University, Indonesia, with number 31/UN.16.2/KEP-FK/2023.

Hatching eggs and chicks were cared for properly during the study following the Animal Ethics Committee Guidelines of IPB University.

DUCK, EXPERIMENTAL DESIGN AND DIET

This study used 96 8-week-old Sikumbang Janti ducks with an average weight of 752.41±81.99 g. The study employed a completely randomized design with four treatments, namely: Z0 (control feed), Z1 (control feed + 30 mg Zn/kg), Z2 (control feed + 60 mg Zn/kg), and Z3 (control

feed + 90 mg Zn/kg) with four replicates (6 animals per replicate). These zinc doses are based on previous research viz: 30 mg Zn/Kg-90 mg Zn/kg (Rusli *et al.*, 2023a; Rusli *et al.*, 2023b). The study was conducted for 8 weeks, the cages used in this study were 1.5 x 1.5 m in size and were equipped with a feeder and drinker to provide ad libitum of feed and drinking water. The feed ingredients used were corn, rice bran, soybean meal, fish meal, CaCO₃, premix, and DL-methionine (Shandong Nhu Amino Acid Co. LTD) and ZnO (75% Zn; Zn-O-India). The ration was prepared based on Sinurat (2000), with a metabolizable energy of 2700 kcal/kg crude protein of 17%.

SAMPLE COLLECTIONS AND SAMPLE ASSAY

Blood sampling was collected (at morning) at the end of rearing from 1 duck per replicate in the brachial vein and then put into a 5 mL vacuum tube. The sample was centrifuged at 3.000 rpm for 10 minutes. Plasma was stored in 1.5 mL tubes at 4°C for further analysis. The procedure for analyzing the minerals of Zn, Calcium (Ca), and phosphorus (P) followed the analytical method of Tausssky and Shorr (1952). Triglycerides were measured by the enzymatic colorimetric analysis method Glycerol Peroxidase Phospat Acid (GPO-PAP), Cholesterol was measured following the Cholesterol oxidase-peroxidase aminoantipyrine (CHOD-PAP) analysis method. While Glucose was measured by Glucose oxidase-peroxidase aminoantipyrine (GOD-PAP) analysis method and Total protein was measured by the biuret analysis method. The malondialdehyde assay was conducted following the analytical method of Capeyron *et al.* (2002).

DATA ANALYSIS

Data were analyzed by analysis of variance (ANOVA) with significance at P<0.05. Significant data were further tested with Duncan's multiple range test. Data analysis used SPSS software version 22.

RESULTS AND DISCUSSION

MINERAL AVAILABILITY

Zn supplementation significantly affects the concentration of Zn, Ca, and P in the blood plasma of Sikumbang Janti ducks (P<0.05) (Table 1). The highest results for increasing the content of Zn, Ca, and P in blood plasma were observed in treatment Z3, which was supplemented with 90 mg Zn/kg.

This study shows that diets with high Zn content affect calcium (Ca) and phosphorus (P) mineral metabolism. In this study, zinc mineral consumption during the study was: 177.46 mg/bird (Z1), 360.35 mg/bird (Z2), 536.34 mg/bird (Z3), and 713.62 mg/bird (Z4), respectively. High mineral intake levels can interact with other minerals, possibly due to competition for nutrient binding (Jammula and fathima,

2024). Excess calcium reduces Zn absorption due to competition (Ao and Pierce, 2013). Previous research showed that Zn supplementation of 80 and 160 mg/kg in duck rations affected Ca and P metabolism (Zhang *et al.*, 2020). However, different results were reported by Sunder *et al.* (2008), who found that Zn supplementation of more than 160 mg/kg in broilers increased Zn levels but resulted in a decrease in ash, Ca, and P content in bones. The elevation in plasma Zn observed in this investigation suggests that an increase in dietary Zn supplementation results in enhanced Zn release into the blood. In certain minerals, an increase in the concentration of Zn in the lumen will be followed by an increase in the absolute quantity absorbed, mainly because mineral absorption is regulated through active and passive mechanisms (Krebs, 2000).

Table 1: Effect of Zn supplementation on mineral availability in blood plasma of Sikumbang Janti duck.

Variables	Treatments				SEM	p-value
	Z0	Z1	Z2	Z3		
Zn (mg/dl)	2.11 ^b	1.63 ^c	1.47 ^d	2.62 ^a	0.13	<0.01
Ca (mg/dl)	11.53 ^b	10.13 ^c	9.62 ^c	12.73 ^a	0.38	<0.01
P (mg/dl)	4.05 ^b	3.50 ^c	2.97 ^d	5.27 ^a	0.26	<0.01

Z0: (Control feed); **Z1:** (Control feed + 30 mg Zn/kg); **Z2:** (Control feed + 60 mg Zn/kg); **Z3:** (Control feed + 90 mg Zn/kg). Means with different superscripts in the same row differ significantly ($p < 0.01$).

BLOOD CONSTITUENTS

Zn supplementation had a significant effect ($P < 0.01$) on the levels of triglycerides, cholesterol, and total protein in the blood plasma of Sikumbang Janti ducks. However, glucose levels did not affect ($P > 0.05$) by Zn supplementation (Table 2). Zn supplementation of 60 mg/kg ration (Z2) resulted in the highest blood serum triglyceride and cholesterol levels compared to the other treatments. In contrast, the highest total protein content was obtained in treatment Z3 (90 mg Zn/kg ration).

The addition of Zn in the diet of Janti Sikumbang ducks in this study caused an increase in plasma triglyceride (Z1-Z2 treatment), cholesterol, and total protein levels. The increase in plasma triglyceride and cholesterol levels was caused by the rise in the proportion of very low-density lipoprotein (VLDL), the primary carrier of triglycerides (Migliorini *et al.*, 2019). This finding is consistent with previous studies that Zn supplementation in broiler diets increased blood lipid levels (Kim and Kang, 2022). Zhao *et al.* (2014) also reported that a diet enriched with ZnNPs (20 mg/kg) resulted in elevated levels of human blood cholesterol. The rise can be attributed to the function of zinc as the primary component of several lipid enzymes. Nevertheless, it enhances serum oxidase (SOD) function to eliminate free radicals.

Table 2: Effect of Zn supplementation in blood plasma constituent of Sikumbang Janti duck.

Variables	Treatments				SEM	p-value
	Z0	Z1	Z2	Z3		
Triglyceride (mg/dl)	306.67 ^b	338.55 ^{ab}	371.87 ^a	254.82 ^c	13.05	<0.01
Cholesterol (mg/dl)	133.87 ^b	135.72 ^b	189.90 ^a	140.47 ^b	6.36	<0.00
Glucose (mg/dl)	240.42	229.92	245.15	283.12	6.52	0.06
Total Protein (g/dl)	4.30 ^a	4.70 ^a	5.70 ^a	6.47 ^b	0.23	<0.00

Z0: (Control feed); **Z1:** (Control feed + 30 mg Zn/kg); **Z2:** (Control feed + 60 mg Zn/kg); **Z3:** (Control feed + 90 mg Zn/kg). Means with different superscripts in the same row differ significantly ($p < 0.01$).

MALONDIALDEHYDE

The effect of Zn supplementation on malondialdehyde (MDA) content in the blood plasma of Sikumbang Janti ducks can be seen in Figure 1. Zn supplementation significantly ($P < 0.05$) reduced MDA content in the blood plasma of Sikumbang Janti ducks. Supplementation of 90 mg Zn/kg in the diet produced the lowest MDA content in blood plasma.

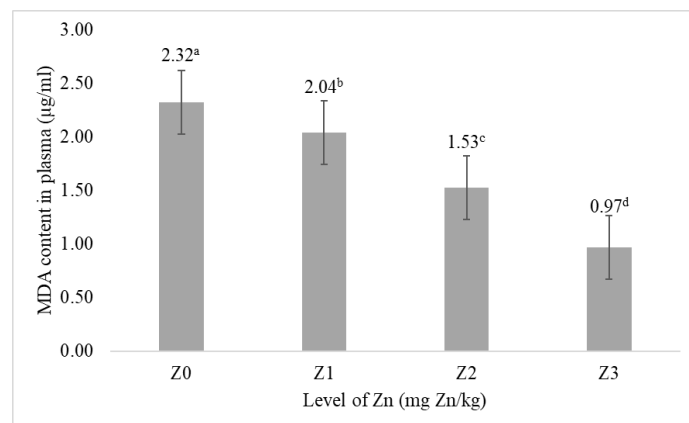


Figure 1: Effect of Zn supplementation in Malondialdehyde (MDA) of Sikumbang Janti duck. Z0 (Control feed), Z1 (Control feed + 30 mg Zn/kg), Z2 (Control feed + 60 mg Zn/kg), and Z3 (Control feed + 90 mg Zn/kg). Means with different superscripts in the same row differ significantly ($p < 0.01$).

Malondialdehyde (MDA) is a significant biomarker for lipid peroxidation and oxidative stress, reflecting the extent of free radical-induced cell damage (Cordiano *et al.*, 2023). High levels of MDA indicate high levels of oxidized lipids, which are associated with decreased antioxidant activity. In this study, the addition of Zn in the diet of Sikumbang Janti ducks decreased plasma MDA levels. This decrease is due to the role of Zn in stimulating the activity of the enzyme superoxide dismutase (SOD), which functions to counter-

act free radicals (Sunder *et al.*, 2008). Zhang *et al.* (2023) explained that Zn plays a structural role in Cu/Zn SOD (SOD1), which is predominantly found in the cytosol. Each subunit of the enzyme contains one copper ion and one zinc ion. The zinc ion is not directly involved in the catalytic reaction but is essential for maintaining the enzyme's structural integrity. It stabilizes the active site geometry required for copper to effectively catalyze the conversion of superoxide. This finding is consistent with previous studies reporting that Zn supplementation reduced MDA levels in broilers (Lee, 2018; Hidayat *et al.*, 2020), laying hens (Qin *et al.*, 2017), and ducks (Zhang *et al.*, 2020).

CONCLUSIONS AND RECOMMENDATIONS

Supplementation of 90 mg Zn /kg in the diet of Sikumbang Janti ducks enhances mineral availability (Ca, P, and Zn) and total protein levels and reduces triglyceride and malondialdehyde (MDA) content in blood plasma. Research is needed on Zn supplementation for other breeds or different environmental conditions.

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NOVELTY STATEMENT

We investigate the utilization of a trace mineral (Zinc) in the feed of endemic ducks from West Sumatra, providing deeper insights into the role of Zinc in supporting duck health.

AUTHOR'S CONTRIBUTIONS

Ridho Kurniawan Rusli: Conceptualization, Methodology, Writing-Original Draft.

Robi Amizar: Formal Analysis, Data Curation, Validation, Visualization.

Zurmiati: Writing-Original Draft, Data Curation, Validation.

Ananda: Writing-reviewing.

Arif Darmawan: Writing-reviewing and editing.

Kusnadidi Subekti: Supervision, Writing-reviewing and editing.

Khalil: Supervision, Writing-reviewing and editing.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest that could inappropriately influence this manuscript.

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