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Effect of organic zinc supplementation into basal diets on productive performance of laying hens

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ABSTRACT

This study was carried out to determine the dietary supplementation of organic zinc on feed intake (FI), feed conversion ratio (FCR), egg production (EP), egg mass (EM) and quality. A total of 120 ISA-Brown layers aged 20 weeks were used in this study. Hens were distributed randomly to four treatments (30 hens of each) with three replicates. The organic zinc was supplemented into basal diet at different concentrations as follows; (T1) 0, (T2) 100, (T3) 200, and (T4) 300 mg/kg. The results showed T2 was recorded improvement significant on FI, and FCR followed by T3. Also, egg mass in T2 was increased significantly compared with T1. The T2 and T3 were significantly higher in average egg production as compared to T1 which was showed the lowest value. There was no significant effect on egg quality when supplemented organic Zn to the diet of layer hens. It might be concluded that the dietary supplementation of 100 mg/kg of organic Zn has improved feed consumption which is reflected in the productivity of laying hens.

Keywords: *Egg production, Egg quality, Feed intake, Laying hens, Organic Zn*

INTRODUCTION

The trace mineral requirements of poultry are not well characterized, and the issue becomes more problematic from the start of production. Zinc (Zn) is a fundamental traced elemental for the whole living community (prokaryote and eukaryote), it plays an essential function in a diverse biological system in all living organisms (Liu *et al.,* 2011). The Zn also has important role in many enzymes as a cofactor and shares in the synthesis of protein, carbohydrate, metabolism process of energy and other bioactive interaction in birds. Furthermore, Zn contributed to the synthesis of DNA and RNA, repair of cellular texture and development, skeleton system and blood thrombus as well as to the rapid growth of poultry (Salim *et al.,* 2012). The Zn is figured out in the diet of poultry in two kinds (inorganic and organic). The form of inorganic grade as zinc oxide (ZnO) (Fawaz *et al.,* 2019) or zinc sulfate ($ZnSO_4$) (Rajabi and Torki, 2021) while organic Zn sources like Zn methionine (Zn-Me) and Zn amino acid complex (ZnAA) (Li *et al.,* 2019). When comparing between two forms of Zn will notice organic trace minerals are chemical complexes made by ions of metal linked to organic material which have complex of polysaccharides, amino acids and peptides, or supply biological availability to metal ions also increase solubility and stability (Gayathri and Panda, 2018; Saeed *et al.,* 2021).

Regarding, organic Zn has been more useful for layer hens also they may be metabolized in a different way when compared with inorganic forms metabolize (Ibrahim *et al.,* 2017). Hence, there is relatively little evidence available on the comparative effects of dietary organic zinc supplementation in laying hens. Therefore, the purpose of this study was to examine the effects of different levels of organic zinc (Availa-Zn) on layer performance and egg characteristic quality.

MATERIALS AND METHODS

Management and Experimental Animal

The experiment was conducted at the farm of poultry, Veterinary Medicine College, University of Fallujah. One hundred twenty laying hens (ISA-Brown) 20-week-old of laying were used in this study. Hens were divided into four treatments (three cages per treatment, 10 birds per cage). Hens were assigned to system of deep litter and all standard practices of poultry management up to 6 weeks of age were applied. The lighting program was 17 hrs light / daily, as well as daily temperature was measured by the highest-lowest degree of temperature by a thermometer placed in the middle of the shed. Hens were vaccinated by following standard vaccination schedule. Hens were adopted on feed with layer mash with one experimental diet (Table 1).

Dietary Treatments

The diet was formulated according to NRC (1994). Dietary treatments inclusion of an organic Zn source (zinc-methionine; Availa-Zn120; Zinpro Corporation, Eden Prairie, MN, USA), distributed as follows; T1 basal diet, T2 basal diet supplemented with 100 mg/kg of organic zinc, T3 basal diet supplemented with 200 mg/kg of organic zinc, T4 basal diet supplemented with 300 mg/kg of organic zinc.

Productive Performance

Feed intake (FI) and feed conversion ratio (FCR) were calculated on a weekly basis, per pen, as indicators of productivity (Alnori 2021; Sani *et al.,* 2021). Each replicate's FI was measured separately. The FCR was calculated as (feed consumed ÷ egg mass). Additionally, egg production was collected for each replicate. The daily collection of eggs was then enforced on a per-hen basis. The egg mass was determined using the formula (average egg weight × egg production).

Egg Quality Parameters

At the end of the study, eggs were collected from each replicate (5 eggs/cages), before broken eggs were on a flat surface the egg weight was recorded separately. The yolk of egg was removed from egg white (albumen) and then weighed. However, eggshell was cleaned with water and then dried up at 40°C / 24 h and was individually measured the weigh by digital accuracy grade to 0.01 g. Egg albumen, shell measured from the varies among the weight of egg before drying the shell (Eisen *et al.,* 1962).

Statistical Analysis

Results of experiments apply the procedure of GLM (SAS, 1997). Comparison and supervision between rates of values applied by Duncan's multiple range test ($P<0.05$).

RESULTS AND DISCUSSION

Feed Intake

Results of the effect of supplementation of different levels of organic Zn into the diet of the ISA-brown layer on FI is shown in Table 2. The treatments showed significant variation ($P<0.05$) in all periods of study as well as the average FI.

Table 1. Composition of the experimental basal diet

Ingredients	Composition (%)
Corn	40.0
Wheat	24.0
Soybean meal (48% protein)	18.0
Wheat bran	8.0
Limestone	6.5
Sunflower oil	1.5
Di-calcium phosphate	1.1
Vitamin-mineral premix	0.5
Sodium chloride	0.3
DL-methionine	0.1
Chemical composition	
Metabolizable energy (kcal/kg)	2829
Crude protein (%)	18.85
Lysine (%)	0.86
Methionine + cysteine (%)	0.68
Methionine (%)	0.41
Calcium (%)	3.4
Phosphorous (%)	0.44
Ratio of energy to protein (%)	150

Premix provided per kilogram of diet: vitamin A, 8,000 IU; vitamin D3, 2,000 IU; vitamin E, 34.5, IU; vitamin K3, 1.8 mg; biotin, 0.15 mg; vitamin B1, 1.2 mg; vitamin B2, 3.2 mg; pantothenic acid, 6.4 mg; vitamin B6, 1.97 mg; niacin, 28 mg; vitamin B12, 0.025 mg; choline, 320 mg; folic acid, 0.38 mg. Mn, 60 mg; Fe, 50 mg; Cu, 4.8 mg; I, 1.25 mg; Se, 0.16 mg; Zn, 0 mg.

The T3 registered the lowest value among other treatments. However, the daily average of feed intake for T2 was reduced significantly compared with T1. The supplementation of organic Zn was effect on FI of laying hens, this finding is inconsistent with that of Ahmadi *et al.* (2013) who stated that supplementing 120 mg/kg of Nano – ZnO increased the FI considerably. However, Tabatabaie *et al.* (2007) observed Feed consumption in a Hy-line layer fed meal enriched with 50 mg/kg organic zinc was considerably lower than in the control group. This finding is similar to ours in this study, it was discovered that supplementing 80 mg/kg of Zn-Met reduced feed consumption more than $ZnSO_4$. (Li *et al.,* 2019). A possible explanation for this might be that the type of Zn organic source could effect on FI level in laying hens. It is possible that the protective mechanisms involved in the effects of organic zinc on reduced food intake are a protective response to ensure survival and maintain relatively normal metabolic levels of this mineral, albeit downregulated levels (Bao *et al.,* 2007). This finding was also reported by Bao *et al.* (2009) who indicated that when zinc levels are insufficient to sustain growth or cellular metabolism, reduced food in-

Table 2. Effect of Different Levels of Supplementation of Organic Zinc on Average Feed Intake (g/kg)

Treat	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	AFI	SEM	p-value
T1	112.43^{a}	124.12^{a}	118.51^{a}	117.59^{a}	131.94^{a}	126.38^{a}	121.82^{a}	2.24	0.02
T2	107.87^{a}	106.15^{b}	106.94^{b}	119.44^{a}	118.98^{b}	119.90^{b}	113.21^{b}	2.19	0.01
T3	97.68^{b}	105.31^{b}	104.62^{b}	105.09^{b}	114.81^{b}	115.27^{ab}	107.13^{b}	2.16	0.05
T4	117.12^{a}	108.52^{b}	112.49^{ab}	117.12^{a}	123.14^{ab}	124.99^{a}	117.39^{ab}	1.99	0.04

T1: (basal diet), T2: (100 mg/kg of organic zinc), T3: (200 mg/kg of organic zinc), T4: (300 mg/kg of organic zinc). ^{a,b} Means in the same row with different superscripts differ significantly at P<0.05. AFI means average feed intake.

take may be due to a survival mechanism.

Feed Conversion Ratio

Table 3 showed a significant effect of fed various levels of organic Zn on FCR from 1st to 6th weeks in all treatments. Generally, T2 and T3 recorded the lowest significant differences (2.24 and 2.17 % respectively) in the average FCR when compared with T1. The current study found that consuming zinc-methionine as an organic form of Zn, resulted in considerable variations in FCR when compared to T1. The impact of organic Zn on FCR in this study is consistently and significantly altered by Zn supplementation and timing of first laying cycle. This suggests that the FCR of laying hens in response to Zn supplementation might be changed depending on the experimental approach or environmental variables (Fawaz *et al.,* 2019). These results are in agreement with Torki *et al.* (2015) findings which showed the FCR of Lohmann LSL laying hens fed a diet supplemented with 40 mg/kg of Zn was reduced when compared to the control group. A previous study showed there were no significant differences as a result of a supplemented diet with different concentrations of organic Zn (Zn-Methionine) (Abd El□Hack *et al.,* 2018). These findings corroborate the ideas of De Grande *et al.* (2020) who reported that significant decrease in FCR was observed when ZnAA (AvailaZn) was used instead of $ZnSO_4$. This reduction in FCR does not appear to be caused by an increase in FI, but rather appears to be an effect of increased weight gain when zinc is provided as ZnAA complexes rather than ZnS.

Egg Production

The results of egg production during first phase of laying was showed in Table 4. The egg production was significantly (P<0.05) increased in T2 and T3 (83.48 and 81.78 respectively) when compared with T1 which was the lower in

Table 3. Effect of Different Levels of Supplementation of Organic Zinc on Feed Conversion Ratio (%)

Treat	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	AFCR	SEM	p-value
T1	2.8^{a}	2.8^{a}	2.49^{a}	2.5^{a}	2.75^{a}	2.6^{a}	2.65^{a}	0.05	0.05
T2	2.2^{b}	2.11^{c}	2.13^{b}	2.4^{a}	2.33^{b}	2.3^{b}	2.24^{b}	0.04	0.03
T3	2.09^{b}	2.17^{c}	2.19^{b}	2.02^{b}	2.32^{b}	2.24^{b}	2.17^{b}	0.03	0.01
T4	2.64^{a}	2.37^{b}	2.36^{ab}	2.44^{a}	2.39^{b}	2.45^{a}	2.44^{ab}	0.03	0.05

T1: (basal diet), T2: (100 mg/kg of organic zinc), T3: (200 mg/kg of organic zinc), T4: (300 mg/kg of organic zinc). ^{a,b,c} Means in the same row with different superscripts differ significantly at P<0.05. AFCR means average feed conversion ratio.

Table 4. Effect of Different Levels of Supplementation of Organic Zinc to the Diet of Hen at First Layer Cycle on Egg Production (%)

Treat	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	AEP	SEM	p-value
T1	71.28^{c}	77.77^{b}	81.94^{b}	79.62^{b}	79.62^{b}	80.55^{b}	78.46^{b}	1.21	0.01
T2	84.72^{a}	85.18^{a}	83.33^{a}	81.94^{a}	82.40^{a}	83.33^{a}	83.48^{a}	0.40	0.05
T3	81.94^{a}	83.79^{a}	81.01^{a}	81.01^{a}	81.01^{a}	81.94^{a}	81.78^{a}	0.35	0.05
T4	76.84^{b}	76.38^{b}	79.16^{b}	78.69^{b}	82.86^{a}	80.55^{a}	79.16^{b}	0.77	0.05

T1: (basal diet), T2: (100 mg/kg of organic zinc), T3: (200 mg/kg of organic zinc), T4: (300 mg/kg of organic zinc). ^{a,b,c} Means in the same row with different superscripts differ significantly at P<0.05. AEP means average egg production.

Table 5. Effect of Different Levels Supplementation of Organic Zinc into Treatment Diets of Hens on Egg Mass

Treat	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	AEM	SEM	p-value
T1	4013.2[c]	4461.3[b]	4744.3[b]	4692.9[b]	4779.9[b]	4854.5[b]	4591.0[b]	99.96	0.01
T2	4884.9[a]	5014.7[a]	5002.5[a]	4970.7[a]	5089.8[a]	5199.7[a]	5027.0[a]	34.37	0.05
T3	4652.0[ab]	4849.2[a]	4763.3[b]	5202.4[a]	4941.5[ab]	5121.1[a]	4921.6[a]	67.31	0.03
T4	4426.2[b]	4496.5[b]	4746.7[b]	4913.3[a]	5126.6[a]	5079.8[a]	4797.7[ab]	93.94	0.05

T1: (basal diet), T2: (100 mg/kg of organic zinc), T3: (200 mg/kg of organic zinc), T4: (300 mg/kg of organic zinc). [a,b,c] Means in the same row with different superscripts differ significantly at P<0.05. AEM means average egg mass.

Table 6. Effect of Different Levels Supplementation of Organic Zinc to the Diet of Hen at First Layer Cycle on Egg Quality Parameters

Treat	Egg Weight	Eggshell Weight	Albumin Weight	Yolk Weight
T1	65.62	8.50	37.12	18.87
T2	66.25	8.75	37.12	18.87
T3	67.62	8.62	38.87	18.62
T4	66.00	8.87	39.00	17.75
SEM	0.38	0.07	0.45	0.23
p-value	0.19	0.98	0.18	0.47

T1: (basal diet), T2: (100 mg/kg of organic zinc), T3: (200 mg/kg of organic zinc), T4: (300 mg/kg of organic zinc).

egg production (78.46). However, T4 showed decreasing in the level of egg yield through the 1st to 4th week of study but in the last two weeks (5 - 6 weeks) the egg production has improved. Organic Zn had no effect on egg weight, egg-shell weight, albumin weight, or yolk weight values in our study. The current findings reveal that treatments T2 and T3 fed on organic Zn produced significantly more eggs than the control group. The findings demonstrated that supplementing organic Zn into the diets of chickens improved egg production (Abd El-Hack *et al.,* 2018). The increased egg production might be related to an increase in sex hormones in hen blood plasma (Xiao *et al.,* 2019; Attallah *et al.,* 2022). This study is consistent with previous findings (Qiu *et al.,* 2020) that suggested trace minerals were important in the generation and production of luteinizing hormones and follicle-stimulating hormones. Because organic Zn may intersect with the endocrine system when chicken layers regulate the creation and excretion of genital hormones across adolescence, feeding organic Zn to them might increase egg quality. The increase egg production in weeks 5 and 6 was similar to the results of a study by Behjatian Esfahani *et al.* (2021) showed that there was a significant difference in egg production between treatments at ages 36 to 40 weeks. The treatments with the highest egg production were those with various levels of organic Zn, while those with the lowest egg production were control groups and inorganic Zn. Adding different levels of zinc to the diet of broiler breeders resulted in a significant increase in the concentration of estrogen and progesterone, suggesting that zinc's role in the production and secretion of reproductive hormones contributes to the increase in egg production (Al-Daraji and Amen 2011).

Egg Mass

Egg mass during the study period was recorded a significant decrease (P<0.05) in T1 fed hens (basal diet) in comparison with T2 (100 mg/

kg) in all periods as well as in the average of egg mass throughout the experiment as shown in Table 5. Several reports have shown found that utilizing varying concentrations of zinc improved egg mass significantly. It is encouraging to compare these results with that found by Abedini *et al.* (2018) observed that egg mass was considerably enhanced in hens fed diets with 40 and 80 mg Nano-ZnO/kg compared with 120 mg/kg or/ and the control group. This study supports evidence from previous observations (Abd El-Hack *et al.,* 2018; Abedini *et al.,* 2018; AL-Obaidi *et al.,* 2020). However, replacement of inorganic Zn with organic sources in aged hens increased egg weight and reduced egg loss without affecting egg production, or FCR (Saleh *et al.,* 2020). This increase in egg mass could be attributable to zinc's role in numerous biochemical and physiological processes (Behjatian Esfahani *et al.,* 2021). This enhancement may also be the result of zinc's participation in the body's protein and energy metabolism (Ibs and Rink 2003). Since egg mass is correlated with egg production, egg mass improved by increasing egg production in hens fed the ZnMet and Zn-Thr-enriched diet compared to other treatments. Our findings concurred with those of Behjatian Esfahani *et al.* (2021), who reported that the incorporation of an organic zinc source into the diet significantly increased egg mass.

Egg Quality

It can be seen from the data in Table 6 that none of these differences in egg weight, eggshell weight, albumin weight and yolk weight were statistically significant. These findings were also reported by Abedini *et al.* (2018) reported that eggshell weight, yolk weight, albumen weight, and height were not affected by supplementing 40, 80, or 120 mg Nano-ZnO/kg to the diet of laying hens. Differences in mineral metabolism at different ages, storage of body, or in different strains of laying hens could be to blame for the somewhat contradictory findings that have been obtained from different studies (Behjatian Esfahani *et al.,* 2021). We anticipated that supplemental dietary Zn would increase eggshell quality since Zn is a major component of the carbonic anhydrase enzyme, which is required for the supply of carbonate ions for eggshell development (Yu *et al.,* 2020). Minerals appear to compete to reduce the availability of other minerals at high levels of supplementation. Calcium and manganese, which are involved in the formation of egg shells, are likely the most important minerals (Abedini *et al.,* 2018). This study finding is contrary to previous studies which have suggested that supports the use of zinc-containing diets for laying hens, as zinc plays a crucial role in shell formation in the uterus and magnum during egg white deposition and the isthmus where eggshell layers are delivered (Travel *et al.,* 2011; Du *et al.,* 2015).

CONCLUSION

The findings that were obtained demonstrated that zinc derived from an organic source, such as Methionine-Zn, possesses superior layer performance in comparison to zinc derived from an inorganic source. However, supplementation of 100 mg/kg organic Zn to the layer diet was shown to be effective in enhancing productivity and maintaining egg quality. Further research should focus on determining the blood metabolic profile of laying hens at a similar concentration.

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CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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