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Effect of Dietary Biozinc Forms on Performance, Digestibility Coefficient, Nutritive Value and Blood Profile in Barki Lambs

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Abstract

The aim of the presented study was an estimation of zinc bioavailability derived from amino acid chelate with glycine, lysine and methionine in growing lambs. 20 lambs at age about 10 weeks and average body weight of 20 kg were randomly divided into 4 groups. Control contain basal diet and 40mg/kg $ZnSO_4$ DM. the 2nd,3rd and 4th groups contain basal diets and 40mg/kg Zn glycine chelate, 40mg/kg Zn lysine chelate and 40mg/kg Zn methionine chelate, respectively. At the end of the experiment, average body weight of lambs fed zinc methionine chelate showed significant improvements than control, zinc lysine and glycine chelate. The blood samples were taken, in tissue samples from liver, kidney and pancreas the content of zinc was determined. Absorption and retention of zinc were higher ($p<0.05$) in lambs receiving amino acid chelate (glycine, lysine and methionine chelate) than control ($ZnSO_4$). The higher content of zinc in soft and hard tissue of lambs which received organic form of zinc might indicate better assimilation and bioavailability of zinc than sulphate form. Among tested organic forms of zinc, the zinc methionine complex was characterized as having the most advantageous property.

Implication

The objective of this experiment was to evaluate dietary $ZnSO_4$, Zn-glycine, Zn lysine and Zn methionine on growth performance, blood serum, and tissue zinc concentration for lambs

Introduction

Mineral bioavailability is influenced by the form of the minerals in the source (feed stuffs). Chemical form of inorganic source and anti nutritional factors like silica, tannins and phytates immensely influence the bioavailability. Chelated forms/organic forms of minerals (Cu-lysine, Zn-methionine) have better bioavailability and lead to improved immunity, production and reproduction In recent years, organic trace mineral sources, such as amino acid chelates and proteinates have been used widely in animal production because of increased mineral bioavailability, lower faecal excretion and reduced environmental waste loading [1,2]. Enhanced bioavailability of a mineral source could reduce the amount of a mineral that is added to a diet to meet the nutritional requirements, which in turn would reduce the amount of mineral excreted [3]. Zinc is an essential trace mineral and plays many significant roles in metabolism as a component of numerous metalloenzymes and transcription factors [4]. It is an activator or an integral part of the action of many enzymes and metalloenzymes. Several studies reported that pharmacological concentrations of inorganic zinc (1,000 to 5,000 mg/kg) added to the weanling pigs could improve growth and feed conversion [5]. Faecal Zn excretion was markedly decreased when lower concentrations of Zn from organic sources were fed to weanling pigs as a replacement for pharmacological doses of Zn as zinc oxide (ZnO) [6,7]. Research indicated that organic zinc had been proposed to provide a higher bioavailability than inorganic zinc in chicks [8] and pigs [9]. Case CL and Carlson MS and Buff CE et al., [6,10] reported that pigs fed 500 mg/kg Zn as an organic Zn-polysaccharide (Zn-PS) complex had similar growth performance but excreted less Zn in the faeces than pigs fed 3,000 mg/kg Zn as ZnO. Supplementation with appropriate zinc glycine chelate (Zn-Gly) can improve the growth performance and immunological capacity of broilers [8].

Material and Methods

Animal and experimental design

This study was carried out at the Noubaria Station; Animal Production Research Institute. 20 barki lambs at age about 10 weeks of 20Kg were divided in 4 experiments. Each group contains 5 lambs all animals were housed in semi open pens. The experimental diets contain 60% concentrate mixture and 40% hay. Concentrate mixture contained 45% yellow corn, 31.5% wheat bran, 5% cotton seed meal, 10% soybean meal, 5% molasses, 2% limestone, 1% salt and 0.5 premix as basal

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diet. The first diet (control) contains the basal diet plus 40 mg of Zn/kg DM as ($ZnSO_4$•$7H_2O$). The second , third and fourth groups contain basal diets and 40mg/kg Zn glycine chelate, 40mg/kg Zn lysine chelate and 40mg/kg Zn methionine chelate, respectively, which was approximately around the Zn recommended levels of NRC 1985 (Table 1).

Digestibility traits

After rearing period two rams from every group, with average body weight of about 25 kg were divided into digestibility balance experiments and fed with concentrate mixture and hay. Each digestibility trial lasted three weeks as preliminary period followed by one week as a collection period. The animals were housed in metabolic cages and beneath each, a stainless steel screen having 4 mm mesh to retain feces but allow free passage to urine, which was collected through a funnel to be easily separated. The animals were fed twice a day at 8.00 am and 16.00 pm. Water was available all time. Feed samples were collected and prepared for proximate analysis. Faeces and urine were collected quantitatively once a day before the morning meal at 8.00, and stored at –10°C. The seven days combined collection was sampled then it was kept for routine analyses. Fecal samples were dried at 60°C for 72 hours (partial drying) and ground through a one mm screen on a Wiley mill grinder. They were composted (20 gm) per sample per treatment per animal for analyses. Digestibility were determined and expressed on dry matter basis. Analyses were carried out according to AOAC 2000.

Analytical procedures

Blood and tissues' samples collection: At the end of the experiment, when animals achieved average body weight of about 40 kg the blood samples were taken, and in the blood serum, after previous wet mineralization, the zinc content was determined with the usage of atomic absorption spectrophotometer Varian., killed and during dissection tissue samples were taken (liver, pancreas, and kidney) [11]. According to the AOAC methodology, in tissue samples as well as faeces and urine, the content of zinc was determined after previous wet mineralization with atomic absorption spectrophotometer. Obtained data, in digestibility experiments, allowed on calculation of apparent absorption and retention of zinc. The level of Zn determined in tissues' samples was used to estimate the bioavailability of zinc from different ones applied in experiment sources.

Preparation of chelate: Zn methionine, Zn lysine and Zn glycine were produced by reacting zinc sulfate with amino acids (methionine, lysine and glycine) at a 2:1 molecular ratio, refluxed for two hours, separated and washed several time with ethanol

Table 1: Chemical composition of concentrate feed mixture (CFM), and hay (on dry matter basis, %).

Item (%)	CFM	Hay
DM	90.36	91.20
OM	90.18	89.48
CP	14.78	10.82
CF	11.96	26.60
EE	3.58	2.80
NFE	59.86	49.26
Ash	9.82	10.52

Statistical Analysis

Means were calculated for all variables by cow within period. Data were analyzed using the mixed procedure of SAS. Differences were tested using the PDIFF option in SAS using a protected ($P < 0.10$) LSD test. Differences were declared significant at a $P < 0.05$; and trends were discussed at a $P < 0.15$, unless stated otherwise.

Results and Discussion

Body weight

The present study showed that ADG was enhanced ($P<0.05$) for lambs fed zinc chelate (zinc lysine and zinc methionine) than control and glycine treatment (Table 2). Ward et al., [9] reported that 250mg/kg of Zn as zinc methionine increased growth performance of weanling pigs equal to that of 2000 mg/kg of Zn as ZnO. Feeding Weanling pigs a diet containing 500 mg/kg of Zn as Zn proteins increased growth performance similar to that of pigs fed a diet containing 3,000 mg/kg of Zn as ZnO in two of three experiments. Contrary to our results, Case and Carlson [6] reported that pigs fed 500 mg/kg Zn as an organic Zn-PS complex had similar growth performance but excreted less Zn in the feces than pigs fed 3,000 mg/kg Zn as ZnO. Haryanto et al., [12] in experiments on sheep indicated that application in their daily rations of zinc methionine had a positive effect on feed utilization. Such effect could be explained by the influence of zinc on fat and protein utilization [13].

Digestibility coefficient, nutritive values and nitrogen utilization

The data of intake, digestibility of different nutrients during metabolism trial and data of daily nitrogen intake excretion and retention are presented in Table 3. The DMI, digestibility of (DM, OM, CP, EE, NDF) and total digestibility nutrients (TDN and DCP) were significantly ($p<0.05$) higher in (zinc lysine and zinc methionine chelate). These results agreed with those obtained by Parsaad et al. [14], who studied mineral supplementation and their influence on nutrients digestibility in buffalo calves and observed that digestibility of DM, CP and CF were improved. Hanafy et al., [15] found that application of chelated mineral mixtures as feed additives may be help to increase nutrients digestibility by lactating buffaloes. Ead et al., [16] showed that the digestion coefficients of OM, NFE and NFC% were higher with seaweed supplementation, using dairy Friesian cows. However S. A. Khan [17] didn't find any effect on DMI in calves

Table 2*:* Growth performance and feed utilization.

Item	Control	Treatments		
		1	2	3
Initial weight (kg)	20.25±42	20.25±55	20.22±63	20.23±72
Final weight (kg)	39.22±32	41.33±48	43.25±54	46.45±69
Gain (kg)	18.97±.10	21.8±.07	23.03±.09	26..22±.03
Average daily gain kg/h/day	0.632±.02	0.726±.04	0.767±.05	0.874±.03
Feed gain ratio (kg:kg gain)	60.88±.03	52.01±.05	48.71±.07	41.38±.08

*Four treatments were designed in order to, Control contain basal diet and 40mg/kg $ZnSO_4$. the 1 group contain basal diets and 40mg/kg DM Zn glycine chelate, group 2 contain , basal diets and 40mg/kg DM Zn lysine chelate and group 3 contain basal diets and 40mg/kg DM Zn methionine chelate, respectively.

feed with level of organic zinc from 26.2 to 85.67 mg/ kg DM. The amino acids, when absorbed by the animal's rumen, enhance the microbial action within the rumen and hence increase the Total Digestible Nutrients (TDN) available from the feed. These results are in accordance with those obtained by Hanafy et al., [15] who found that application of chelated mineral mixtures as feed additives may be help to increase nutritive values by lactating buffaloes. Metals ions may be absorbed as part of metal peptide complex, thereby facilitated absorption of zinc. Zinc from zinc methionine may have been associated with ligands that facilitated Zn uptake [18].

Zinc balance

The zinc amount taken by lambs during digestible balance experiment in all groups was similar (Table 4). However, the animals receiving zinc in organic form (lysine and methionine) excreted less zinc in feces and urine ($p<0.05$) than control and glycine chelate. The highest apparent absorption and retention of zinc were stated in lambs receiving zinc methionine chelate. Excretion of zinc in faeces and urine were significantly higher in control than chelated form. Zinc methionine showed significantly p ($0<0.05$) the highest apparent absorption and retention of zinc metal, while the control had the lowest level. The improvement in minerals absorption and retention of chelated form may be attributed to that mineral was found in organic form which enhanced their metabolic utilization [19]. The use of organic minerals source can improve intestinal absorption of trace elements as they reduce interference from agent that form insoluble complex with the ionic trace elements [20]. These applied zinc compounds had an influence on the content of this trace element in lambs which receiving zinc lysine and methionine had higher zinc level in blood serum than zinc glycine and sulfate (Table 5). One of the causes of different results obtained could be the fact that absorption of zinc is affected by interactions during digestion and absorption. Zinc in the form of inorganic might be transformed from original dietary compound into other species before reaching the final site of absorption. It is assumed that soluble inorganic form of Zn is more sensitive to attack by phytate or other chelating agents than organic forms of zinc. This can be a reason for higher differences in concentration of zinc in blood plazma and tissues for chelated form with (methionine and lysine) than control inorganic form. The organic forms of zinc amino acids complexes had a positive

Table 3: Dry matter intake, digestion coefficients, cell wall constituents, nutritive values and nitrogen utilization of experimental rations.

Criteria	Control	Treatments		
		1	2	3
DM intake, g/h/d				
hay	407.07 ± 27.92	395.82 ± 37.58	368.26 ±18.18	338.26 ±18.18
CFM intake, g	745.91 ± 17.86	740.98 ± 8.99	736.63 ± 14.26	722.58 ±14.26
Total DMI, g	1155.98 ± 32.28	1134.83 ± 29.33	1122.02 ± 26.15	1085.02 ± 26.15
Digestion coefficients (%)				
DM	65.93 ± 0.87b	66.91 ± 0.73a	66.19 ± 0.67b	69.25 ± 0.77a
OM	66.40 ± 0.80b	64.44 ± 0.52a	65.70 ± 0.48b	68.82 ± 0.45a
CP	57.45 ± 1.00b	55.69 ±0.55a	59.71 ± 0.18ab	62.88 ± 0.14a
CF	55.83± 1.49b	55.18 ± 1.5a	57.81 ± 0.88ab	60.58 ± 0.98a
EE	73.84 ±.43b	72.79 ± 0.78a	75.87 ± 0.98b	79.56 ± 0.58b
NFE	68.67 ± 0.64b	65.03 ± 0.27a	69.56 ± 0.78b	74.96 ± 0.97b
Nutritive values (%)				
TDN	63.55 ± 0.72b	62.63 ± 0.53a	65.14 ± 0.49b	68.55 ± 0.47b
DCP	5.89 ± 0.03b	5.45 ± 0.19a	6.32 ± 0.06a	6.98 ± 0.22a
Cell wall constituents %				
NDF	57.89 ± 0.66c	58.48 ± 0.51a	61.99 ± 0.72b	63.54 ± 0.65b
ADF	55.39 ± 0.26b	54.69 ± 0.65a	58.95 ± 0.48a	60.32 ± 0.73a
ADL	45.93 ± 0.18b	46.88 ± 0.33a	49.83 ± 0.42a	50.12 ± 0.98b
Nitrogen utilization (g/h/d)				
N-Intake	18.54 ± 0.42	18.69 ± 0.17	18.78 ± 0.36	18.89 ± 0.57b
N-Absorbed (NA)	10.82 ± 0.35b	10.59 ± 0.02a	10.97 ± 0.25	11.32 ± 0.18a
N-Retention (NR)	2.83 ± 0.15c	3.47 ± 0.06a	3.77 ± 0.13b	3.98 ± 0.98a
NR% of NI	15.03 ± 0.54b	17.81 ± 0.11a	18.86 ± 0.43b	23.81 ± 0.11a
NA% of NI	26.14 ± 0.58c	38.60 ± 0.52a	31.58 ± 0.69b	38.60 ± 0.52a

*Four treatments were designed in order to, Control contain basal diet and 40mg/kg $ZnSO_4$. the 1 group contain basal diets and 40mg/kg DM Zn glycine chelate, group 2 contain , basal diets and 40mg/kg DM Zn lysine chelate and group 3 contain basal diets and 40mg/kg DM Zn methionine chelate, respectively.

Table 4: Apparent absorption, % and retention of zinc, mg/day/head.

Items	Experimental groups			
	Control	**1**	**2**	**3**
Zinc in take/mg	40 mg/kg DM	40 mg/kg DM	40 mg/kg DM	40 mg/kg DM
Execreted in faeces In urine /mg	22.23ᵃ±3.5 9ᵃ±4.8	20.25ᵃ±3.2 8ᵇ±3.5	15.24ᵃ±2.7 5ᵇ±3.4	13.12ᵃ±2.5 3ᵇ±45
Retention Zn mg/day /head	8.77 ᵃ±2.5	11.75 ᵇ±3.5	19.76 ᵃᵇ ±2.5	23.88 ᵃᵇ ±3.7
Absorption%	21.92 ᵃ±1.3	29.37 ᵇ±1.4	49.40 ᵃᵇ ±1.5	59.70ᵇ ±1.7

*Four treatments were designed in order to, Control contain basal diet and 40mg/kg $ZnSO_4$. the 1 group contain basal diets and 40mg/kg DM Zn glycine chelate, group 2 contain, basal diets and 40mg/kg DM Zn lysine chelate and group 3 contain basal diets and 40mg/kg DM Zn methionine chelate, respectively.

Table 5: The concentration of zinc in blood serum and selected tissues of experimental lambs.

Items	Experimental groups			
	Control	1	2	3
Blood serum	15.3 ᵃ ±1.2	15.6 ᵃ ±1.7	16.3 ᵃ ±1.8	18.7 ᵃ ±2.3
liver	80.4 ᵃ ±1.3	80.5 ᵃ ±1.3	81.3 ᵃ ±2.4	83.4 ᵃ ±3.3
Pancreas	72.4 ᵃ ±1.4	72.7 ᵃ ±2.3	73.0 ᵃ ±2.3	74.8 ᵃ ±2.3
kidney	94.2 ᵃ ±1.5	94.7 ᵃ ±2.2	95.1 ᵃ ±2.2	97.2 ᵃ ±2.3

*Four treatments were designed in order to, Control contain basal diet and 40mg/kg $ZnSO_4$. the 1 group contain basal diets and 40mg/kg DM Zn glycine chelate, group 2 contain , basal diets and 40mg/kg DM Zn lysine chelate and group 3 contain basal diets and 40mg/kg DM Zn methionine chelate, respectively.

effect on accumulation of this microelement in selected soft and hard tissues. On the other hand, Spears [21] had not indicated the influence of zinc form (Zn-methionine vs. zinc oxide) in lambs on its level in blood serum. The higher content of zinc was stated in liver, pancreas, kidney from lambs which obtained zinc methionine than in tissue of lambs obtained zinc lysine and glycine chelate. As Spears [21] stated the increase of zinc amount in tissues with application of organic forms of this element did not depend only on zinc source but also on zinc level in ratio. Rojas et al., [22] used for lambs zinc oxide , zinc sulphate and zinc complexes with methionine and lysine indicated that concentrations of zinc in soft tissues of lambs (kidney, liver, pancreas) which received organic forms of this element were higher than in animals which received sulphate and oxide. Kincaid et al., [23] indicated that application in calves' nutrition of zinc lysine and zinc-methionine in amount of 300 mg of Zn/kg of feed caused the increase of content of this element in liver in comparison with animals received zinc oxide. The higher zinc content in calves tissues and lambs indicated also comparison the availability of zinc from zinc-proteinate and zinc sulphate [1,24]. The application of different forms of zinc changed the pathways of absorption of this element. Zinc bounded with amino acids is absorbed in amino acid absorption pathways, and as this complex it could be deposited together with amino acid into the proteins of tissues increasing the element concentration.

Conclusion

The application of amino acid complexes of zinc caused the increase of apparent absorption and retention of zinc, and improved zinc status of lambs which was indicated by higher zinc level in blood serum. The higher zinc content in soft and hard tissues of lambs which received organic forms of zinc could indicate the better assimilation and bioavailability of zinc from these forms than from sulphate. Among tested organic forms of zinc, the zinc-methionine complex was characterized by the most advantageous property.

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