KUFA JOURNAL FOR VETERINARY MEDICAL SCIENCES

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Effect of Inorganic and Nano-zinc oxide on Feed Intake, Weight Gain and Feed Conversion of Awassi Lambs

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ABSTRACT

Zinc is one of the components of many enzymes that performs catalytic, structural and regulatory functions and important in the processes of cell metabolism, regulating appetite, growth and immune function. This research aimed to determine the effect of zinc on the intake and growth data of lamb sixteen Awassi male lambs (4.5-5 months age and 23.38± 0.95 kg body weight) were use. They were divide into four groups. The first group (R1) was fed concentrated feed without additives, while zinc oxide (ZnO) at 45 mg/kg DM of concentrated feed to the rest of the groups: the second group (R2) inorganic ZnO. The third group (R3) commercial Nano-ZnO. The fourth group (R4) ZnO synthesized using green methods. The roughage feed was provide freely throughout the study. The results showed a significant increase in the average daily weight gain (ADG) and total weight gain (TG) for the second group, which respectively reached 156.07 g/day and 10.92 kg compared to 141.07 g/day and 9.87 kg for the first group. The statistical analysis showed a significant improvement in the food conversion ratio from 7.40 g DM/g weight gain (WG) for the control unit to 6.54 g DM/g WG for the group of lambs fed concentrated feed containing inorganic ZnO. The addition of zinc from a non-Nano source led to a decrease in rough feed consumption and an important boost in the lambs' daily and total weight gain, as well as feed conversion ratio.

ARTICLE INFO
Article history:
Received: 11 June 2024
Accepted: 5 August 2024
Published: 31 Desember 2024
DOI: https://doi.org/10.36326/kjvs/2024/v15i216535
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P- ISSN: 2077-9798
E- ISSN: 2959-8478

KEYWORDS: Lamb, Weight gain, Zinc oxide, Nano zinc oxide.

INTRODUCTION

Zinc (Zn) is one of the minerals that has many beneficial effects on mammalian health such as disease resistance [1]. DNA synthesis, cell growth, cell division [2,3], cell metabolism, interpreting the genetic code, regulating appetite, and immune function [4]. Zinc is one of the components of many enzymes structure and serves as catalytic, structural, and regulatory functions within the body. However, zinc cannot be stored in the animal tissue, therefore, continuous zinc supply to the animal's diet is necessary for maintaining the physiological functions that depend on zinc [5].

Dietary recommendations for zinc in sheep range from 20 to 51 mg/kg DM of feed intake, depending on the physiological state of the animal [6]. Appropriate concentrations of zinc in diets fed to sheep have shown to be beneficial in many economic aspects, including but not limited to growth, reproduction, and wool characteristics. [7].

Nanotechnology is a new scientific field and is widely applied in many biological research such as treatment, nutrition and disease diagnosis [8,9]. Globally, nanotechnology is an emerging and promising technology in agriculture, especially in the livestock sector [10]. The nutritional value of feed materials included in the composition of rations can be enhanced with nanoparticle supplements [11]. Nanotechnology has the potential to have significant positive effects on animal health and thus on productive and reproductive performance [12, 13].

The objective of the current study was to evaluate the effect of diet supplementation with ZnO and Nano-ZnO on feed intake, weight gain, and feed conversion ratio (FCR) of lambs.

MATERIALS AND METHODS

Experimental site

The study was conduct on the experimental fields of the Department of Animal Production, College of Agriculture, Al-Qassim Green University (Babylon, Iraq). Laboratory analyses were conduct in the animal nutrition laboratories in the same department.

Animals, rations and management

Sixteen Awassi lambs, age range 4.5-5 months, average weight 23.38±0.95kg, were divide into four groups (four males per group) according to their average live body weight to ensure similar initial weights in all groups. The animals were house in individually fed pens. The first group was provide with a control diet (R1) and fed the experimental diet, which consisted of a mixture of barley, ground yellow corn, wheat bran, and soybean meal. The other groups were fed the same experimental diet with the addition of 45 mg/kg DM to each source of inorganic ZnO (R2), commercial nanoparticles 30 NM (R3) of Chinese origin, and nanoparticles synthesized using green methods in the laboratories of the Ministry of Science and Technology (Baghdad, Iraq).

The lambs were fed a concentrated feed mixture at 3% of their live body weight, divided into two periods at 8:00 am and 4:00 pm. The amount of focused feed provided to the lambs was adjust weekly according to the change in body weight. While crushed wheat straw was given freely to the lambs and clean drinking water was provided freely. The trial period lasted 70 days, preceded by a 30-day introductory period. The percentages of components of the concentrated feed are barley 44.84%, yellow corn 17.84% in crushed form, wheat bran 30%, and soybean 4.88% after conducting a chemical analysis of all components of the feed with the addition of urea 0.44%, table salt 1%, a mixture of vitamins and minerals 0.5%, and limestone 0.5%, which were mixed manually in the field. (Table 1)

Green synthesis of Nano-zinc oxide

The method described by Bashi et al [14] was follow with some modifications, in preparing Nano-ZnO using the green synthesis method in the laboratories of the Ministry of Science and Technology/Baghdad, by dissolving 1 g of ZnO in 50 ml of deionized distilled water. Add 1 g of curcumin to the solution. The mixture is stirrer using a magnetic stirrer at room temperature for 24 hours after which the mixture is place in the Shaker incubator at a temperature of 40 degrees Celsius for 18 hours or until the color changes from pale yellow to reddish yellow, the sediment is separate by a centrifuge. Central at a speed of 3000 rpm for 20 minutes. It is wash with distilled water from which the ions is been removed several times. The precipitate is separate and dried in an electric oven at a temperature of 50 Co and then ground it well with a ceramic mortar and sifting the result is to obtain a fine powder and keep it in the refrigerator until used. In the study, samples of the resulting powder were taken to conduct the necessary tests to indicate the Nano size and some other tests that support this. The Nano size was 72.68 nanometers.

Table 1.
Chemical composition g/Kg DM of concentrated feed and its components and roughage feed

Chemical composition	Wheat bran	yellow corn	Barley	Soybean meal	Concentrated feed	Wheat straw
Dry matter	92.62	90.91	92.45	92.38	89.83	91.41
Organic matter	93.25	94.23	93.57	88.05	95.14	90.16
Crude protein	14.40	8.36	10.57	45.44	14.92	2.95
Ether extract	2.25	4.52	2.50	1.74	4.38	1.94
Crude fiber	13.73	3.16	6.37	5.40	4.15	37.45
Nitrogen−free extract	62.87	78.19	74.13	35.47	71.69	47.82
Metabolic energy(MJ/Kg DM)	1.19	1.35	1.27	1.12	1.33	0.95

* The level of ME was estimate according:
(MJ/ Kg DM) = 0.012 CP + 0.013 EE + 0.005 CF + 0.014 NFE.

Estimating intake from experimental diets

The intake of concentrated and roughage was estimated separately by weighing the feed provided in the morning using an accurate scale and weighing the remaining feed after 24 hours and before serving the next feed while changing the amount of concentrated feed provided weekly at 3% of the live BW of the lambs. The difference between the first and second weights is concentrated and rough feed intake.

Estimate growth parameters

The lambs were weighed weekly during the preliminary period using a digital scale with a capacity of 300 kg. The final weight (FW) after the end of the preliminary period was consider the initial weight (IW) of the lambs during the experimental period and the start of the actual experiment. The monitor is the growth and weight of the lambs and the resulting change for feed and according to the actual weight of the lambs the weight was continued. The weekly weight of the lambs throughout the 10 weeks, which represents the experimental period and the weight at the end of the tenth week. It was consider the final weight of the lambs.

The amount of total weight gain (kg) represents the difference between the final weight of the lambs and their starting weight. The daily weight (g) is the result of dividing the total weight gain by 70, the number of days of the actual experimental period, while the result of dividing the average intake of concentrated feed and crushed wheat hay together. The average daily weight gain represents the food conversion factor.

Statistical analysis

The statistically analyzed according to the Completely Randomized Design (CRD) by using the statistical program (SAS), the averages of the coefficients were compare using the Duncan test (1955).

RESULTS AND DISCUSSION

Feed intake

Table 2 shows that the results of the statistical analysis showed that there was no significant effect when adding the sources of ZnO for all groups on all intake data of dry matter, crude protein, and organic matter for concentrated, total, and digested feed. These results are consistent with the findings of many studies [15, 16, 17].

Table 2.
Effect of the source of zinc oxide added to the concentrated feed fed to Awassi lambs on intake data from experimental diets (g/day ± standard error)

Nutritional component	Zinc oxide source: 45 mg/kg DM				Significant
	R1	R2	R3	R4	
DM intake concentrated feed	816.17 22.13±	867.85 52.89±	792.15 35.42±	787.24 21.97±	N.S
DM intake roughage	227.71[a] 14.33±	153.83[b] 6.26±	205.94[ab] 19.95±	198.21[ab] 23.75±	*
Total dry matter intake	1043.88 34.27±	1021.68 56.10±	998.09 45.10±	985.44 42.53±	N.S
TDM digested	773.84 44.88±	894.77 70.47±	793.23 62.37±	775.77 42.04±	N.S
CP intake concentrated feed	116.87 3.17±	124.27 7.57±	113.43 5.07±	112.73 3.14±	N.S
CP intake roughage	6.71[a] 0.42±	4.53[b] 0.18±	6.07[ab] 0.58±	5.84[ab] 0.70±	*
Total crude protein intake	123.59 3.50±	128.81 7.66±	119.50 5.26±	118.58 3.69±	N.S
TCP digested	97.21 4.50±	110.83 9.25±	98.55 6.38±	94.66 1.55±	N.S
OM intake concentrated feed	776.51 21.06±	825.67 50.32±	753.65 33.70±	748.98 20.90±	N.S
OM in intake roughage	205.30[a] 12.92±	138.70[b] 5.64±	185.68[ab] 17.98±	178.71[ab] 21.41±	*
Totally organic matter intake	981.81 31.96±	964.36 53.20±	939.33 42.26±	927.68 39.36±	N.S
TOM digested	743.76 42.09±	852.34 66.68±	762.42 58.52±	751.25 39.65±	N.S

- The means with different letters horizontally differ significantly at the level* ($P<0.05$) and (N.S) is not significant.
- R1: control. R2: ZnO. R3: Nano-ZnO. R4: Green synthesis Nano-ZnO.

In addition, Al-Ghazali [18] found that nano-ZnO did not affect ($P<0.05$) the amount of feed consumed, while some other studies indicated a significant increase ($P<0.05$) of 10% for feed consumed when 5 mg of zinc was added. Nano per kg dry matter of lamb diet [19].

Hosseini Vardanjani et al [20] found a significant increase ($P < 0.05$) when inorganic ZnO and nano-ZnO were added to ewes' diets at a concentration level of 40 mg/kg DM in dietary intake on a total dry matter basis. From 1647 and 1654 g/day after day when adding inorganic ZnO and nano-ZnO to 1859 and 1801 g/day when not adding.

While the current study data recorded a significant decrease ($P<0.05$) in the intake data of rough feed for the second treatment, inorganic ZnO in dry matter was 153.83 g/day, crude protein was 4.53 g/day, and organic matter was 138.70 g/day compared to 227.71, 6.71, and 205.30 g/day in succession to the first treatment without addition. As for the sources of Nano and synthetic ZnO, the data came in dry matter 205.94 and 198.21 g/day, crude protein 6.07 and 5.84 g/day, and organic matter 185.68 and 178.71 g/day, which were significantly equal to the diets fed without addition and the additive. It has inorganic ZnO.

The results of the current study are similar to the results obtained by Al-Ghazali [18]. There were no significant differences ($P>0.05$) in intake of dry matter, organic matter, and nitrogen-free extract when dosing lambs with Nano-ZnO, while the study indicated an improvement in intake of rough feed at a dosage level of 15 mg/animal/day. While the results did not agree with Hosseini Vardanjani et al [20] when adding 5 mg of Nano-ZnO/kg DM. Dry matter intake improved significantly ($P<0.05$) from roughage from 0.652 to 0.752 kg/head/day for the comparison unit.

The results of the current study indicated that the natural concentrations of zinc in the diet and the added concentrations of inorganic ZnO under study were within the recommended normal limits, which in turn does not affect intake, despite the clear increase the amount of ingested and digested dry matter when adding inorganic ZnO. Many studies have indicated the role of zinc as an appetite stimulant and the positive effect of zinc on microbial fermentation processes [21]. Zinc deficiency also increases gene expression of the hormones cholecystokinin and leptin, which act as satiety signals and regulate energy consumption [22].

Roughage feed intake

(Table 3) indicates a significant decrease (P<0.05) in the ratio of intake from roughage to the total intake from forage when adding an inorganic ZnO source at a concentration level of 45 mg/kg DM as the ratio of intake from crushed wheat straw reached. The intake from the total diet based on dry matter was 15.13%, based on organic matter 14.45%, and based on crude protein 3.54%, compared to the intake of crushed wheat hay. The total intake from the feed for the control unit that fed on feed with no additives was 21.76% based on dry matter 20.86% based on organic matter and 5.42% based on crude protein. The results of the study conducted by Arelovich et al [23] were somewhat similar to the results of the current study with a decrease in the amount of roughage consumed that did not significant (P>0.05) when adding zinc chloride and zinc sulphate at a concentration level of 460 mg/kg of feed Center provided for Corydale lambs.

Table 3.

The effect of the source of zinc oxide added to the concentrated feed fed to Awassi lambs on the ratio of intake of roughage to the total ration (% ± standard error)

Nutritional component	Zinc oxide source: 45 mg/kg DM				Significant
	R1	R2	R3	R4	
Intake DM	21.76[a] 0.82±	15.13[b] 0.68±	20.58[a] 1.52±	19.93[a] 1.58±	*
Intake OM	20.86[a] 0.79±	14.45[b] 0.65±	19.72[a] 1.47±	19.09[a] 1.54±	*
Intake CP	5.42[a] 0.24±	3.54[b] 0.18±	5.09[a] 0.44±	4.90[a] 0.47±	*

- The means with different letters horizontally differ significantly at the level* (P<0.05) and (N.S) is not significant.
- R1: control. R2: ZnO. R3: Nano-ZnO. R4: Green synthesis Nano-ZnO.

In contrast to the current results, Farghaly et al [24] indicated that there was an increase in the intake of roughage to the total diet, but it was not significant (P>0.05) when inorganic sources of zinc (ZnSo4) and organic sources (Zinc methionine).

The decrease in milled wheat straw intake in the second treatment may be due to an improvement in the rumen environment and thus an increase in microbial digestion [23]. The slow passage of feed materials to the posterior parts of the digestive tract led to an increase in anaerobic fermentation of nutrients, especially crude fiber [25]. This was reflect positively in an increase in the digestibility coefficient of most nutrients, especially crude fiber, with increased energy. This has been confirm by many previous studies that adding inorganic zinc sources to lambs' food leads to improving the process of digestion of nutrients and the rumen environment [26, 24].

Growth performance

It is noted from (Table 4) that there are no significant differences (P>0.05) in the starting weight of the lambs between the studied treatments as a result of the random distribution of the lambs to the experimental units and the convergence of the average live weight of the lambs under study, which falls within the range of 24.17-24.05 kg. It is also noted that there is no significant effect (P>0.05) among the treatments, although the second treatment adding inorganic ZnO recorded the highest average final BW of 35.10 kg.

The results of the current study are consistent with the results of several studies [27, 28]. The results of the study conducted by Grisakova et al [29] were similar to the results of the current study, with no statistically significant differences (P>0.05) in the average final live weight after feeding lambs on diets supplemented with different sources of zinc at a concentration level of 80 mg/ kg. Al-Ghazali [18] indicated the same results of giving Awassi lambs orally with three concentrations of 0, 15, and 30 mg of nano-ZnO/animal/day.

Table 4.

Effect of the source of zinc oxide added to the concentrated feed fed to Awassi lamb on growth data (unit ± standard error).

Growth performance	Zinc oxide source: 45 mg/kg DM				Significant
	R1	R2	R3	R4	
Initial BW (kg)	24.17 1.40±	24.17 2.09±	24.15 0.79±	24.05 0.97±	N.S
Final BW (kg)	34.05 1.37±	35.10 2.11±	32.92 0.79±	32.11 0.52±	N.S
Total gain (kg)	9.87^{b} 0.05±	10.92^{a} 0.21±	8.77^{c} 0.23±	8.81^{c} 0.25±	**
ADG (g/day)	141.07^{b} 0.78±	156.07^{a} 3.13±	125.35^{c} 3.39±	125.90^{c} 3.63±	**

- The means with different letters horizontally differ significantly at the level of * (P<0.05) and ** (P<0.01) (N.S) not significant.
- R1: control. R2: ZnO. R3: Nano-ZnO. R4: Green synthesis Nano-ZnO.

Despite this, the results of the study conducted by Aliarabi et al [16] differed from the results of the current study with a significant increase (P<0.05) in the final BW of lambs fed with concentrated feed supplemented with inorganic ZnO in the form of zinc sulphate at a level of 40 mg/kg DM.

Ali et al [30] showed that adding 30 nm nanoparticles of ZnO to lamb diets resulted in a significant increase (P<0.05) in the final BW of lambs.

As for ATG and ADG, it was observed in (Table 4) that there was a highly significant increase (P<0.01) in ATG and ADG from 9.87 kg and 141.07 g/day. For the control unit, it reached 10.92 kg and 156.07 g/day, respectively, when adding inorganic ZnO at a concentration level of 40 mg/kg DM. It was noted that the addition of two Nano-ZnO sources led to a highly significant decrease (P<0.01) from the control unit in the average increase. The total weight and average daily weight gain were 8.77 kg and 125.35 g/day when adding chemically manufactured Nano-ZnO, and 8.81 kg and 125.90 g/day when adding Nano-ZnO created using biological or green methods.

The results of the current study are consistent with many of the results of previous studies [26, 15, 24]. Aliarabi et al [16] found a significant increase (P<0.01) in ADG When feeding lambs with diets containing zinc. The results of the study did not agree with [19, 27]. Singh et al [31] indicated similar results that there was no significant difference (P>0.05) in ATG and ADG when feeding young lambs Jalauni on diets supplemented with 60 mg of zinc in the form of non-Nano ZnO.

A recent study indicated a significant increase (P<0.05) in ADG when lambs were fed diets containing 6 mg/kg DM of Nano-ZnO. The researcher stated that increasing the level of Nano-ZnO concentration to 12 mg/kg DM of ZnO did not significantly affect the ADG of the lambs [30].Zinc supplementation increased average daily and total body weight. This may be due to the increased digestibility coefficient of nutrients [32]. Zinc participates in the production and secretion of growth hormone, and interacts with other hormones related to growth in one way or another, such as testosterone, thyroid hormones and insulin. [2] Several studies have indicated that the addition of non-nano ZnO has a positive effect on average daily gain and that proper growth of ruminants requires a relatively higher supply of Zn [33].

Food conversion efficiency

(Table 5) shows the effect of the added source of zinc oxide on the feed conversion factor. The results of the statistical analysis showed a significant improvement (P<0.05) in the feed conversion ratio calculated based on total dry matter intake and total organic matter intake when adding inorganic zinc oxide to the concentrated feed compared to adding commercial ZnO nanoparticles and adding Nano-ZnO prepared using biological methods. There was no significant difference (P>0.05) between the group of lambs that were fed concentrated feed without supplements and the group of lambs that were fed concentrated feed with ZnO added. This is due to the natural level of zinc in concentrate feed fed to lambs without supplementation, which may meet the animal's minimum needs for sustainability and growth almost normally.

Table 5.

Effect of the source of zinc oxide added to the concentrated feed fed to Awassi lambs on the feed conversion ratio (g intake/g daily weight gain ± standard error)

Growth performance	Zinc oxide source: 45 mg/kg DM				Significant
	R1	R2	R3	R4	
Total dry matter ingested/g daily weight gain	7.40^{ab} 0.27±	6.54^{b} 0.34±	7.98^{a} 0.42±	7.80^{ab} 0.63±	*
Dry digested matter ingested/g daily weight gain	5.48 0.32±	5.74 0.48±	6.36 0.63±	6.18 0.45±	N.S
Total organic matter ingested/g daily weight gain	6.96^{ab} 0.25±	6.18^{b} 0.23±	7.51^{a} 0.40±	7.34^{ab} 0.59±	*
Ingested organic matter/g daily weight gain	5.27 0.30±	5.47 0.45±	6.11 0.59±	5.98 0.43±	N.S
Total crude protein intake/g daily weight gain	0.87 0.02±	0.82 0.04±	0.95 0.05±	0.93 0.06±	N.S
Ingested crude protein/g daily weight gain	0.68 0.03±	0.71 0.05±	0.79 0.06±	0.75 0.03±	N.S

- The means with different letters horizontally differ significantly at the level* (P<0.05) and (N.S) is not significant.
- R1: control. R2: ZnO. R3: Nano-ZnO. R4: Green synthesis Nano-ZnO.

The results of the current study are consistent with the findings of Jia et al [15] when adding an inorganic zinc source to the diet of goats, FCR improved significantly (P<0.01). It is also consistent with the study conducted by Aliarabi et al [16] who observed a significant increase (P<0.01) in FCR when adding 40 mg of inorganic zinc sources to lamb diets. The study conducted by Alimohamady et al [34] produced similar results and observed that there was a significant improvement (P<0.01) in the FCR.

The improvement in FCR in the current study may be due to the decrease in the intake of rough feed (Table 3). Many studies indicated that adding any of the organic and inorganic sources of zinc led to an increase in ADG by approximately 20% [35, 16, 34]. Several studies have found that rams fed rations supplemented with zinc had lower bacterial diversity in the rumen than other rams [36], yet had a higher daily weight gain and tended to be more efficient in feed conversion factors [37].

Despite the findings of previous literature and the current study. Garg et al [26] concluded that adding zinc sulphate Lamb diets did not significantly affect (P<0.05) the FCR. A similar pattern (P>0.05) was achieved in FCR when adding a different source of zinc to the lambs diets [35]. These results are also consistent with [38, 29].

A study conducted on lambs found that adding non-Nano zinc and Nano zinc did not significantly affect (P>0.05) FCR [19]. In another study, Al-Ghazali [18] pointed out that Dosing Awassi lambs with Nano-ZnO did not significantly affect (P>0.05) the FCR. The lack of improvement in FCR for the third and fourth treatments may be due to the lack of influence on the intake of feed materials provided to the lambs, especially crushed wheat straw, by the addition of Nano-ZnO. The results are consistent with many studies [19, 18].

CONCLUSION

Supplementing the lambs' diets with inorganic ZnO improved the intake of rough feed, the daily and total weight gain of the lambs, and the feed conversion factor, while high concentrations of Nano-ZnO did not affect most of the studied values.

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