MENOUFIA JOURNAL OF ANIMAL, POULTRY AND FISH PRODUCTION

https://mjapfp.journals.ekb.eg/

EFFICIENCY OF NANO ZINC SUPPLEMENTATION ON GROWTH PERFORMANCE, DIGESTIBILITY, RUMEN PARAMETERS, BLOOD BIOCHEMISTRY AND IMMUNITY STATUS OF BARKI SHEEP

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Received: Mar. 9, 2023 Accepted: Mar. 19, 2023

ABSTRACT: A completely randomized design was used in a growth trial for using thirty male lambs in three similar groups (ten lambs/ group). Lambs were on average body weights 28.2 ± 0.72 kg and aged 7 months. Body weights of lambs were recorded at the start of the experiment and biweekly through the experimental period which lasted for 98-day. Lambs were received a basal diet (control, C) that included Berseem hay at level of 40% and concentrate feed mixture at level of 60% of their overall growth requirements. The first group received the control ration without any additives, while for the second and third groups, the control ration was supplemented with Nano zinc oxide either 6 mg Nano zinc oxide /kg DM, T1 or 12 mg Nano zinc oxide / kg DM, T2. A digestibility trial was carried out at the end of the growth trial on 12 rams (4rams/rations). Ruminal contents were collected via stomach tube at 0, 2, 4 and 6 h post-morning feeding to monitor the *p*H and estimate the concentration of NH_3-N, and total volatile fatty acid (VFA). Blood serum metabolites determined were total protein, albumin, globulin, urea, creatinine, blood glucose, AST and ALT. Data revealed that adding nZnO in both levels lead to an increase in body weight. Total gain and ADG followed the same pattern. Digestibility of all nutrients was not significantly different between the experimental groups. Nutritive value as TDN improved due to nZnO supplementation. No significant differences between the three experimental groups for all N balance data. All the animals were in positive N balance. No difference was reported for *p*H value. Supplementing diets with nZnO increased ammonia nitrogen significantly at all times of incubation. Values of VFA followed the same pattern. Total serum protein significantly decreased from 6.18 for C to 6.05 and 6.12g/dl for T1 and T2, respectively. Globulin followed the same pattern being 2.51, 2.37 and 2.47g/dl for the same respective order. Albumin values however did not differ. No differences were reported for all other blood parameters. Immunoglobulin increased significantly due to the Nano zinc supplementation.

Key words: Nano zinc, performance, digestibility, N balance, fermentation, blood parameters.

INTRODUCTION

Zinc (Zn) is an essential micro-element; it is a part of several enzymes that are necessary for the nutrients metabolism in animals (Jia *et al.*, 2008). Unfortunately the body cannot store Zn; therefore, a constant dietary supply is required for appropriate physiological functions (Zalewski *et al.*, 2005). Zinc oxide is the main source of Zn used in animal feed manufacturing in spites of low solubility (Wedekind and Baker, 1990). Zinc oxide nanoparticles (ZnO NPs) are one of the most important metal oxide with many significant features such as chemical and physical stability, high catalytic activity, effective antibacterial activity as well as intensive ultraviolet (UV) and infrared (IR) adsorption. They are used in an array of products and wide range of applications (Buazar, *et al.*, 2015; Buazara *et al.*, 2016 and Yusof *et al.*, 2017). Nano zinc oxide (nZnO) is used recently for supplementation in ruminant diets. Nano zinc has larger surface area than normal zinc which

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allows greater solubility leading to better utilization in animals. The effects of this substance need to clarify its potential utility as a dietary supplement in ruminants. Therefore, this experiment was carried out to study the effect of different levels of nZnO on performance, digestibility, and nitrogen balance of Barki sheep.

MATERIAL AND METHODS

The present study was conducted at Animal Production Department, Faculty of Agriculture, Menoufia University (Shebin El-Kom) in compliance with Menoufia University guidelines for dealing with animals in scientific research, with the approval of Ethics Committee. (The Institutional Animal Care and Use Committee-Menoufia University (IACUC) - (Reference No. MUFAG/F/AP/1/23).

This study was carried out according to the cooperation protocol between the Animal Production Research Institute (APRI), Agriculture By-product Utilization Research Department, and the Faculty of Agriculture, Menoufia University, the Animal Production Department, (Reference No. 2429.22.2019).

Nano Zinc oxide (ZnO NPs)

Figure (1) shows the structure and morphology of the Nano zinc, which was studied using transmission electron microscopy (TEM) by TOPCON 002B with a point-to point resolution of 0.18 nm and a voltage of 200 kV. Transmission electron microscopic analysis provided exact morphology and size of ZnO NPs acquired from optimized synthesis conditions and revealed predominantly irregular to nearly hexagonal and quasi-spherical with legitimately agglomeration (Fig. 1A,B). This is a typical phenomenon of interaction of moisture and ZnO and inter-particle interactions (Van der Waals, electrostatic and magnetic forces) 49,50. The average size of zinc nanoparticles was 30 nm, which is comparable to protein globules' (2–10 nm) diameter, the size distribution patterns reveal that the synthesized NPs ranged from nm with an average size similar hexagonal—quasi-spherical zinc oxide nanoparticles. DNA helix's (2–nm) diameter, and cell membranes' (10–nm) thickness. This allows them to easily penetrate cells and cell organelles. Research indicates that nanoparticles (NPs) larger than 10 nm, which can enter the nucleus, are more harmful than smaller NPs (Huo *et al.*, 2014).

Growth performance

Thirty male lambs were randomly selected in a completely randomized design and separated into three comparable groups (ten lambs/ group) in a 98-day growth trial. Lambs were on average body weight 28.2 ± 0.72 kg and aged 7 months. Body weights were recorded at the start of the experiment and biweekly thereafter. Animals were received a basal diet (Table 1; control, C) that included Berseem hay at level of 40% and concentrate feed mixture at level of 60% of their overall growth requirements according to NRC (1985). The first group received the control ration without any additives, while for the other two groups, the control ration was supplemented with Nano zinc oxide either 6 mg Nano zinc oxide /kg DM, T1 or 12 mg Nano zinc oxide / kg DM, T2. The concentrate feed mixture consists of yellow corn, 52%; cotton seed meal, 17.0%; soybean meal, 10.0%; wheat bran, 18.0%; limestone, 1.7%; sodium chloride, 1.0%; mineral and vitamin mixture, 0.3%. Feeds were offered daily in two portions at 09:00 a.m. and 16:00 p.m. Animals had free access to drinking water at all times. The chemical composition of ingredients and ration are presented in Table (1).

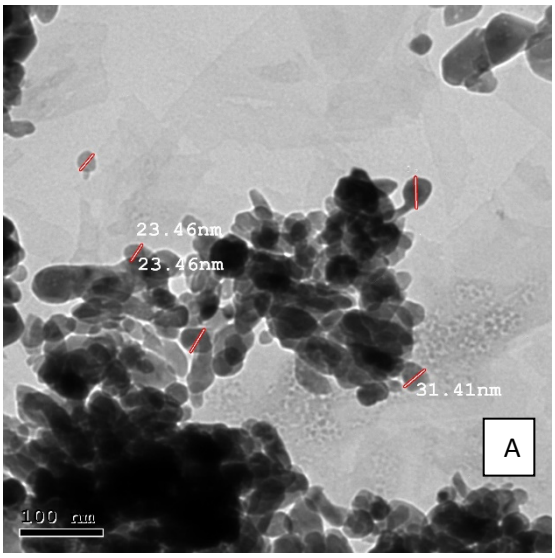
Digestibility and nitrogen balance

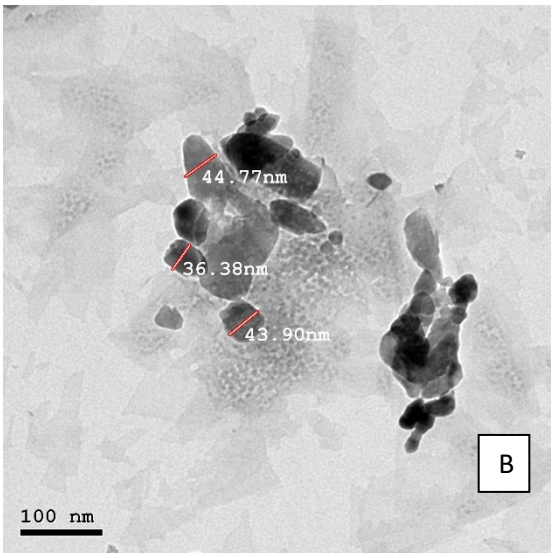
A digestibility trial was carried out at the end of the growth trial on twelve adult rams (4 rams/rations; 46.58±0.71 kg). Animals were housed individually in metabolism cages (1.6m x 0.53m) and fed the previous three rations according to NRC (1985) for 21 days as an acclimatization period and a subsequent 5 days collection period. The amount of daily excreted feces per each animal was recorded, mixed, and 10% of the represented samples were extracted and dried for 48 hours at 70ºC. After being processed through a 1 mm sieve on a Wiley mill grinder, feed and fecal sub samples were stored

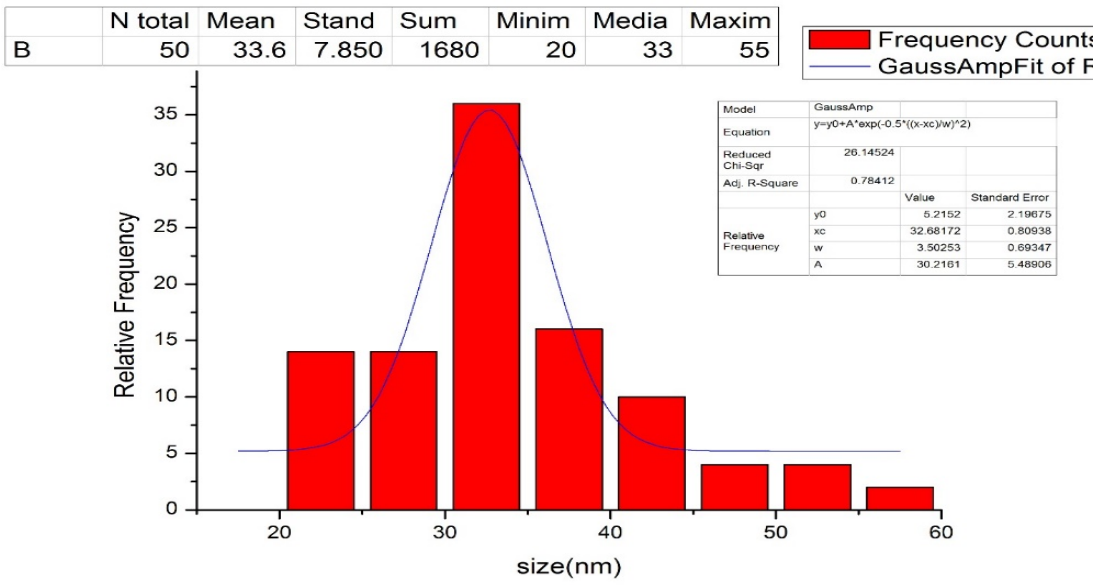
for further analysis. Urine samples were collected daily; the urine volume was measured and 10% subsamples was stored in plastic jars and frozen for later analysis. Fifty millimeters of 4 N H_2SO_4 were added daily to urine collection buckets to prevent ammonia volatilization. The chemical composition of Feed, fecal samples and Nitrogen content in urine samples were analyzed according to the AOAC (2016). Nutritive ratio (NR) and Nutritive quality index (NQI) for the experimental rations were calculated by the following equations according to McDonald *et al.* (1983).

NR: Nutritive ratio = (TDN-DCP)/ DCP.

NQI: Nutritive quality index = (CP %) × (DMD %) /100







Transmission electron microscopic image of Ak-ZnO NPs (A) low magnification (X80k), (B) high magnification (X120k), and (C) particle size distribution histogram.

Figure (1). Transmission electron microscopic images of Nano zinc.

Table 1: Chemical composition (%) of the experimental feeds and rations.

Item	Experimental feeds and ration		
	Berseem hay	CFM	Control ration
Dry Matter	88.94	88.04	88.41
Percent of nutrients on DM basis			
Organic matter	88.97	90.31	89.68
Crude protein	12.63	14.59	13.77
Crude fiber	31.02	9.93	18.39
Ether extract	2.57	3.76	3.24
Nitrogen free extract NFE	42.75	62.03	54.28
Ash	11.03	9.69	10.32

CFM (concentrate feed mixture) : yellow corn 52%, cotton seed meal 17.0%,soybean meal 10.0%, wheat bran 18.0%, limestone 1.7%, sodium chloride 1.0%, mineral and vitamin mixture 0.3%.

Rumen fermentation

Samples of rumen contents were collected via stomach tube at 0, 2, 4 and 6 h after feeding to monitor the *p*H and estimate the concentration of NH_3-N, and total volatile fatty acid (VFA). The Rumen *p*H was immediately measured by a digital *p*H meter (Model HI 8424). Free ammonia-nitrogen (NH_3-N) in rumen liquor samples were analyzed according to AOAC (2016). Total volatile fatty acids (TVFAs) were estimated by the steam distillation method as described by Warner (1964).

Blood biochemistry and Immunological parameters

Blood serum criteria; total protein, albumin, globulin, urea, creatinine, blood glucose, AST and ALT were determined using standard kits supplied by Spectrum, Germany.

Immunoglobulin A, immunoglobulin G and Interleukin 2 concentrations in serum were estimated using single radio-immuno-diffusion methods derived primarily from the works of Fahey and McKelvey (1965) and Mancini *et al*. (1965). These methods are specific for the quantitative determination of individual protein groups in biological fluids.

Data were statistically analyzed using the General Linear Model Procedure of the SAS software (SAS 2004). The statistical model used to analyze the data was as follow:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where: Y_{ij} = Parameters under analysis, μ = Overall mean, T_i = the effect of the ith treatment and e_{ij} = Random error. Mean comparisons were evaluated using Duncan's (1955) Multiple Range test.

RESULTS AND DISCUSSION

Data in Table (2) present the growth performance of the experimental sheep; it reveals that adding nZnO in both levels lead to increased body weight during the experimental period, differences were significant at week 8 and thereafter. Final body weight was 44.41, 47.83 and 47.03kg; difference between both levels T1 and T2 was not significant. Total gain (kg) and ADG (g) followed the same pattern being 16.21 and 165.4 for the control group, 18.88 and 192.7 for group T1 and 18.09 and 184.6 for group T2. Working with Iranian Angora goat kids (Zaboli *et al.,* 2013) and with *Jalauni* male lambs (Singh *et al*., 2019) did not find any effect on average daily gain due to supplementation of nZnO .; the zinc level in the basal ration may have been adequate for normal growth of *Jalauni* lambs which could be the reason for non-significant effect on growth performance. Finding of Belewu and Adewumi (2021) reveled that dry matter intake and average daily gain significantly increased ($P<0.05$) across the groups with increasing levels of nano zinc oxide fed to West African Dwarf goats. According to Tag-El Din (2019)

rabbits fed diet enriched with various amounts of Nano-Zn or Nano-Se had higher (P>0.05) live body weight at 12 weeks than the control. Additionally, rabbits fed diet supplemented with 60 mg Nano-Zn or 0.3 mg Nano- Se/kg recorded the higher (P>0.05) value of body weight gain and feed conversion ratio comparing with the control group at the whole experimental period (6-12 weeks of age), while protein efficiency ratio were insignificantly improved.

The effect of nZnO supplementation on the nutrient digestibility, nutritive value and N-balance is shown in Table (3). Digestibility of all nutrients was not significantly different between the experimental groups. Nutritive value as TDN improved due to nZnO supplementation being 63.05, 64.59 and 64.12 for groups C, T1 and T3. While, DCP and NR did not differ. The nutritive quality index (NQI) increased significantly due to nZnO supplementation being 8.76, 9.13 and 9.12, for the same respective order. Singh *et al*. (2019) found that all studied groups showed a similar apparent digestibility of DM, OM, CP, NDF, and ADF. Earlier, Jadhav *et al.* (2008) reported that nutrient digestibility was unaffected by Zn supplementation in buffalo calves at levels of 0, 35, and 70 ppm. In a Similar vein, there was no difference in the digestibility of CP, EE, NDF, ADF and cellulose in crossbred cattle supplemented with 0, 35 and 70 ppm Zn in basal diet containing more than 25 ppm Zn (Mandal *et al.,* 2007). All the animals were in positive N balance. Working with rabbits, Tag-El Din (2019) found that dietary treatment (Nano-Zn or Nano-Se) had no significant effect on all studied nutrients digestibility and carcass traits.

Data of nitrogen balance (Table 3) revealed no significant differences between the three experimental groups for all N balance data; intake, fecal, urinary and nitrogen retention; N balance and biological values showed the same pattern. All the animals were in positive N balance in different studies with different animal receiving nZnO (Mandal *et al.,* 2007; Jadhav *et al.,* 2008 and Singh *et al*., 2019).

Table 2: Growth performance as affected by Nano zinc supplementation

Weeks	Treatments			SEM	*P.* value
	C	T1	T2		
Initial BW (kg)	28.2	28.94	28.93	0.55	0.574
2 weeks	29.97	30.79	30.81	0.59	0.546
4 weeks	31.89	32.82	33.07	0.52	0.285
6 weeks	34.05	35.26	35.24	0.54	0.235
8 weeks	36.50^{b}	38.09^{a}	37.99^{ab}	0.67	0.073
10 weeks	38.99^{b}	41.39^{a}	41.05^{a}	0.43	0.004
12 weeks	41.68^{b}	44.61^{a}	44.19^{a}	0.33	< 0.001
Final BW (kg)	44.41^{b}	47.83^{a}	47.03^{a}	0.49	< 0.001
Total gain (kg)	16.21^{b}	18.88^{a}	18.09^{ab}	0.73	0.064
ADG (g)	165.40^{b}	192.70^{a}	184.60^{ab}	0.08	0.063

C: basal diet without additive (control) . T1: control diet supplemented with 6 mg Nano zinc oxide /kg DM. T2: control diet supplemented with 12 mg Nano zinc oxide /kg DM. ADG: average daily gain. SEM: standard error of means.

[a ,b] and [c] means within each row with different superscript differ significantly.

Table 3: Nutrient digestibility, nutritive value and nitrogen balance of sheep as affected by Nano zinc supplementation.

Items	Treatments			SEM	*P.* value
	C	T1	T2		
Nutrient digestibility (%)					
Dry matter, DM	65.30	67.07	66.98	0.55	0.096
Crude protein, CP	67.37	70.55	68.38	1.08	0.289
Crude fiber, CF	61.84	63.14	63.04	0.61	0.286
Nitrogen free extract, NFE	69.12	71.01	71.14	0.93	0.284
Ether extract, EE	69.41	68.16	67.15	0.81	0.306
Nutritive value (%)					
TDN	63.05^{b}	64.59^{a}	64.12^{ab}	0.46	0.092
DCP	9.25	9.60	9.45	0.15	0.284
NR	5.82	5.73	5.79	0.05	0.80
NQI	8.76^{b}	9.13^{a}	9.12^{a}	0.06	0.019
Nitrogen balance (g/d)					
Nitrogen intake, NI	32.66	32.66	32.66	---	---
Fecal nitrogen, FN	10.66	9.62	9.99	0.48	0.131
Urinary nitrogen, UN	11.01	10.72	11.02	0.30	0.732
Nitrogen balance, NB	10.99	12.31	11.64	0.47	0.239
Biological value, BV%	50.48	53.42	51.29	0.93	0.444

C: basal diet without additive (control). T1: control diet supplemented with 6 mg Nano zinc oxide /kg DM. T2: control diet supplemented with 12 mg Nano zinc oxide /kg DM. TDN: total digestible nutrients. DCP: digestible crude protein. NR: Nutritive ratio. NQI: Nutritive quality index. SEM: standard error of means.

[a ,b] and [c] means within each row with different superscript differ significantly.

The effect of nZnO supplementation on rumen parameters in sheep as affected is presented Table (4). No difference was reported for *p*H value except for T1 at 4 and 6 hours after feeding which was lower. Supplementing diets with nZnO increased ammonia nitrogen significantly at all times of incubation. Values of VFA followed the same pattern of NH_3-N; it increased from 9.79 up to 11.6 meq/100ml at 4h of incubation. The respective values at 6h of incubation were 8.66, 9.33 and 9.21 meq/100ml rumen liquor. Chen *et al*. (2011) investigated the effect of nZnO supplementation at different levels (from zero to 400 mg/kg DM) on rumen fermentation parameters. Nano zinc supplementation improved the growth of rumen microorganism, increase microbial protein synthesis and increase energy utilization.

There is increase in VFA concentration, microbial protein production and fermentation of organic matter, however, the concentration of NH_3-N was adversely affected by addition of 100-200 mg nano zinc oxide /kg at 12h of incubation.

The tested blood parameters as affected by dietary nZnO are presented in Table (5). Total serum protein significantly (P<0.07) decreased from 6.18 for C to 6.05 and 6.12g/dl for T1 and T2, respectively. Globulin followed the same pattern being 2.51, 2.37 and 2.47g/dl for the same respective order (P<0.07). Albumin values however did not differ. No differences were reported for all other blood parameters. The serum metabolites were comparable and within the normal physiological range in lambs. Najafzadeh *et al.* (2013) reported that lambs supplemented with nano zinc at the rate of 20 mg/kg BW showed a higher level of creatinine in the serum. Lambs may have elevated serum creatinine levels because they were exposed to large dosages of nZnO (360–400 mg/d). Thus, groups fed with both levels of Zn supplementation showed equivalent nutritional utilization and growth performance; however, Zn bioavailability was greatly enhanced by nZnO, though. In light of this, supplementing with 20 ppm of nZnO may be preferable.

Table 4: Rumen parameters in sheep as affected by Nano zinc supplementation.

Incubation hour	Treatments			SEM	*P.* value
	C	T1	T2		
***P*h**					
0	6.74	6.71	6.67	0.03	0.667
2	6.53	6.84	6.52	0.07	0.347
4	6.61[a]	6.53[b]	6.62[a]	0.16	0.014
6	6.67[a]	6.58[b]	6.68[a]	0.02	0.012
NH_3-N, mg/dl					
0	13.28	13.84	13.75	0.14	0.339
2	17.37[b]	17.89[a]	17.63[ab]	0.15	0.061
4	18.19[b]	19.04[a]	18.93[a]	0.17	0.002
6	15.48[ab]	15.82[a]	14.87[b]	0.27	0.051
VFA, meq/dl					
0	7.09	7.21	7.12	0.46	0.339
2	7.37[b]	7.69[a]	7.56[ab]	0.10	0.061
4	9.79[b]	11.6[a]	11.27[a]	0.13	0.002
6	8.66[b]	9.33[a]	9.21[a]	0.09	0.051

C: basal diet without additive (control) . T1: control diet supplemented with 6 mg Nano zinc oxide /kg DM.
T2: control diet supplemented with 12 mg Nano zinc oxide /kg DM. SEM: standard error of means.
[a ,b] and [c] means within each raw with different superscript differ significantly.

Table 5: Blood criteria of sheep as affected by Nano zinc supplementation

Parameters	Experimental diets			SEM	*P*. value
	Control	T1	T2		
Total protein (g/dl)	6.18[a]	6.05[b]	6.12[ab]	0.02	0.073
Albumin (g/dl)	3.67	3.68	3.65	0.02	0.517
Globulin (g/dl)	2.51[a]	2.37[b]	2.47[ab]	0.04	0.07
Glucose (mg/dl)	61.77	62.20	62.19	0.59	0.857
Urea(mg/dl)	33.04	31.86	30.67	1.26	0.486
Creatinine (mg/dl)	1.27	1.26	1.27	0.01	0.195
AST U/L	107.06	106.81	106.87	1.07	0.986
ALT U/L	117.65	117.61	117.25	1.27	0.971
IgA, mg/dl	28.47[b]	29.99[a]	29.57[a]	0.19	0.006
IgG, mg/dl	127.15[c]	130.64[a]	129.22[b]	0.37	0.003
Interleukin2 2 (Pg/ml)	76.32	76.26	77.23	0.75	0.639

C: basal diet without additive (control) . T1: control diet supplemented with 6 mg Nano zinc oxide /kg DM. T2: control diet supplemented with 12 mg Nano zinc oxide /kg DM. AST: Aspartate transaminase. ALT: Alanine transaminase. IgA: Immunoglobulin A. IgG: immune globulin G. SEM: standard error of means.
[a ,b] and [c] means within each raw with different superscript differ significantly.

Belewu and Adewumi. (2021) illustrated that there were no significant differences in the mean serum glucose values between the treated groups, while the addition of nano zinc oxide led to significant differences in total protein and blood urea nitrogen levels when compared to other treatments. There was no significant difference in the alanine aminotransferase activities between the treatments, but there was a significant difference ($P<0.05$) in the aspartate aminotransferase activities, with lower values being obtained in the group that received higher

levels of treatment than the other treatments. Tag-El Din (2019) reported that there were no significant differences between the experimental rabbit groups in studied plasma criteria by dietary supplementation of Nano-Zn or Nano-Se as compared with the control group.

Immunoglobulin increased significantly ($P<0.003$) due to the Nano zinc supplementation; values of IgA were 28.47, 29.99 and 29.57 mg/dl, for groups C, T1 and T3. The respective values for IgG were 127.15, 130.64 and 129.22mg/dl. Zinc deficiency reduces immune responses and disease resistance (Chesters, 1997).

Conclusion

In this study, the administration of nano zinc oxide at the levels of 6 mg and 12 mg grams per kg dry matter in the diets fed to Barki sheep groups had positive effect on growth performance and blood criteria. Thus, nano zinc oxide provides additional insight on more bio-available zinc source, as a result. Due to the increase in surface area and surface activity of nano minerals, they have a far greater potential as mineral feed supplements for animals, even at much lower doses than the conventional sources. Present study recommends the supplementation of nano zinc oxide at the levels of 6 and 12 mg per kg DM for sheep to improve the growth performance, digestibility, feed utilization and blood criteria. Immunology was also improved by nano zinc oxide supplementation.

REFERENCES

AOAC. (2016). Official Methods of Analysis. Association of Official Analytical Chemists. 20th ed. USDA, Washington, DC., USA.

Belewu, A. and Adewumi, D. (2021). Effect of green syntheses nano zinc oxide on performance characteristics and haemato-biochemical profile of West African dwarf goats. Anim. Res. Internat. 18(1): 3938-3946.

Buazar, F., Alipouryan, S., Kroushawi, F. and Hossieni, S. A. (2015). Photodegradation of odorous 2-mercaptobenzoxazole through zinc oxide/hydroxyapatite nanocomposite. Appl. Nanosci. 5, 719–729.

Buazara, F., Bavi, M., Kroushawi, F., Halvani. M., Khaledi-Nasab.A and Hossieni, S. (2016) Potato extract as reducing agent and stabiliser in a facile green one-step synthesis of ZnO nanoparticles. J. Exp. Nanosci. 11, 175–184.

Chen, J., Wang, W. and Wang, Z. (2011). Effect of nano-zinc oxide supplementation on rumen fermentation in vitro. Chin. J. Animal Nutr. 8: 23

Chesters, J.K. (1997). Zinc: in O Dell BL, Sunde R.A. editors. Handbook of nutritionally essential minerals elements. New York: Marcel Dekker Inc: p 185-230.

Duncan, D.B. (1955). Multiple range and multiple F tests. Biometrics, 11:1-42.

Fahey, J.L. and McKelvey, E.M. (1965). Quantitative determination of serum immunoglobulins in antibody-agar plates. J. Immunol., 94: 84–90.

Huo, S., Shubin, J., Xiaowei, M., Xiangdong, X., Keni, Y., Anil, K., Paulc, C., Jinchao, Z., Zhongbo, H. and Xing, J.(2014). Ultrasmall gold nanoparticles as carries for nucleus-based gene therapy due to size-dependent nuclear entry. ACS Nano.24;(6): 5852-62

Jadhav, S.E.; Garg, A.K. and Dass, R.S. (2008). Effect of graded levels of zinc supplementation on growth and nutrient utilization in male buffalo calves. Anim. Nutr. Feed Technol. 8: 65-72.

Jia, W.; Xiaoping, Zh.; Wei, Zh.; Jianbo, Ch.; Cuihua, G. and Zhihai, J. (2008). Effects of source of supplemental zinc on performance, nutrients digestibility and plasma zinc status in Cashmere goats. Small Rumin. Res. 80: 68-72.

Mancini, G.; Carbonara, A.O. and Heremans, J.F. (1965). Immunochemical quantitation of antigens by single radial immune-diffusion. Immuno. chemical., 2: 235–254.

Mandal, G.P.; Dass, R.S.; Isore, D.P.; Garg, A.K. and Ram, G.C. (2007). Effect of zinc supplementation from two sources on growth, nutrient utilization and immune response in male crossbred cattle. Anim. Feed Sci. Technol.138: 1-12.

McDonlad, P.; Edward, R.A. and Greenhalgh, J.F.D. (1983). Animal nutrition. Third edition. ISBN 0582407079, 244-245.

Najafzadeh, H.; Ghoreishi, S.M.; Mohammadian, B.; Rahimi, E.; Afzalzadeh, M.R.; Kazemivarnamkhasti, M. and Ganjealidarani, H. (2013). Serum biochemical and histopathological changes in liver and kidney in lambs after zinc oxide nano particles administration. Vet. World, 6: 534-537.

NRC (1985). National Research Council, Nutrient Requirements of Sheep, Sixth Revised Edition, 1985, National Academy Press, Washington, D.C.

SAS (2004). SAS User's Guide: Statistics. Edition 9.1. SAS Institute Inc., Cary, NC.

Singh, K.K.; Maity, S.B and Maity, A. (2019). Supplementary effect of different levels of Nano zinc oxide on zinc bioavailability and blood metabolites in lambs. Indian J. Anim. Nutr. 36 (1): 83-87.

Tag-El Din, Noha T.H. (2019). Effect of dietary nano-zinc and nano-selenium addition on productive and physiological performance of growing rabbits at fattening period. Egyptian J. Nutr. And Feed. 22(1): 79-89.

Yusof, H. M., Mohamad, R., Zaidan, U. H. & Abdul Rahman, N.(2017) Microbial synthesis of zinc oxide nanoparticles and their potential application as an antimicrobial agent and a feed supplement in animal industry: a review. J. Anim. Sci. Biotechnol. 10, 10–57.

Warner, A.C.I. (1964). Production of *volatile* fatty acids in the rumen. Methods of measurements. Nutr. Abstr. And Rev. 34: 339-352.

Wedekind, K.J. and Baker, D.H. (1990). Zinc bioavailability in feed-grade sources of zinc. J. Anim. Sci. 68: 684-689.

Zaboli, K.; Aliarabi, H.; Bahari, A. A. and Abbas Ali pourkabir, R. (2013). Role of dietary nano-zinc oxide on growth performance and blood levels of mineral. J. Pharmaceut. Health Sci. 2: 19-26.

Zalewski, P.D.; Ai, Q.T.; Dion, G.; Lata, J.; Chiara, M. and Richard, E.R. (2005). Zinc metabolism in airway epithelium and airway inflammation: basic mechanisms and clinical targets: A review: Pharmacol. Therap. 105: 127-149.

تأثير إضافة النانو زنك على أداء النمو، الهضم ، قياسات الكرش ,كيمياء الدم والحالة المناعية للأغنام البرقي

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الملخص العربي

تم استخدام ثلاثين ذكرًا من الحملان البرقي في تجربة تصميم عشوائي كامل حيث قسمت الحيوانات في تجربة نمو إلى ثلاث مجموعات تجريبية (عشرة حملان / مجموعة) وكان متوسط عمر الحملان ٧ أشهر و متوسط وزن الجسم ٢٨,٢ كجم ± ٠,٧٢كجم . تم تسجيل أوزان الحملان في بداية تجربة النمو والتي استغرقت ٩٨ يومًا وكذلك تم الوزن بشكل دوري كل أسبوعين خلال فترة التجربة. تم تغذية الحيوانات على عليقة أساسية (المجموعة القياسية ، **C**) وكانت عبارة عن دريس برسيم عند مستوى ٤٠٪ ومخلوط علف مركز عند مستوى ٦٠٪ من إجمالي الاحتياجات طبقا ل **NRC (1985)**. قدمت العليقة الأساسية للمجموعة الأولى بدون إضافات ، بينما تلقت المجموعتين الآخرتين العليقة الأساسية مضاف اليها أكسيد نانو زنك بمعدل ٦ مجم نانو زنك أكسيد / كجم مادة جافة (**T1**) أو ١٢ مجم أكسيد نانو زنك / كجم مادة جافة (**T2**). أجريت تجربة الهضم بعد انتهاء تجربة النمو على ١٢ كبش (٤ كباش / معاملة). تم تجميع عينات سائل الكرش قبل التغذية مباشرة وعند ٢ و ٤ و ٦ ساعات بعد التغذية باستخدام اللي المعدي لتسجيل قيم **pH** الكرش وقياس تركيز أمونيا الكرش والأحماض الدهنية الطيارة بالكرش. تم تجميع عينات الدم عبر الوريد الوداجى لقياس كلا من البروتين الكلي ، الألبيومين ، الجلوبيولين ، جلوكوز الدم ،وظائف الكلى وانزيمات الكبد (**AST** و **ALT**) في سيرم الدم . أشارت النتائج المتحصل عليها الى أن إضافة أكسيد النانو زنك في كلا المستويين أدى إلى زيادة وزن جسم الحملان ووصلت الزيادة في وزن الجسم الى مستوى المعنوية بداية من الأسبوع الثامن لصالح المجموعات المعاملة . اتبعت الزيادة الكلية في وزن الجسم ومعدل النمو اليومي نفس النمط. لم تكن معاملات هضم جميع العناصر الغذائية مختلفة بشكل كبير بين المجموعات التجريبية الثلاثة. تحسن مجموع المركبات الغذائية المهضومة (**TDN**) نتيجة اضافة أكسيد النانو زنك. لم تكن هناك فروق معنوية بين المجموعات التجريبية الثلاث لجميع بيانات ميزان النيتروجين و كان ميزان النيتروجين موجبا في جميع المجموعات التجريبية. انخفضت معنويا قيم **pH** الكرش فى المجموعة الثانية **T1,** (٦ مجم أكسيد نانو زنك / كجم مادة جافة) عند ٤ و٦ ساعات بعد التغذية مقارنة بالمجموعة القياسية والمجموعة الثالثة, **T2** (١٢مجم أكسيد نانو زنك / كجم مادة جافة) واللتين لم يكن بينهما اختلافات معنوية . أدت اضافة أكسيد النانو زنك إلى زيادة تركيز أمونيا الكرش بصورة معنوية في جميع أوقات التحضين. اتبعت قيم الأحماض الدهنية الطيارة نفس النمط. انخفض بروتين الدم الكلى من ٦,١٨ لـ **C** إلى ٦,٠٥ و ٦,١٢ جم / ديسيلتر في **T1** و **T2** على التوالي. اتبع الجلوبيولين نفس النمط وسجل قيم ٢,٥١ و ٢,٣٧ و ٢,٤٧ جم / ديسيلتر لنفس ترتيب المجموعات التجريبية , ومع ذلك لم تختلف قيم الألبيومين معنويا. لم تكن هناك فروق معنوية لباقي قياسات الدم الأخرى. أدت اضافة أكسيد النانو زنك الى ارتفاع قيم الجلوبيولين المناعي بشكل ملحوظ مقارنة بالمجموعة القياسية. وكانت جميع قيم قياسات المناعة في حدودها الطبيعية.....