Egyptian J. Nutrition and Feeds (2015), 18(2) Special Issue: 383-390

EFFECT OF DIETARY SUPPLEMENTAL ZINC SOURCE AND LEVEL ON GROWTH PERFORMANCE, DIGESTIBILITY COEFFICIENTS AND IMMUNE RESPONSE OF NEW ZEALAND WHITE RABBITS

Samia Z. Meshreky[1]*; Sabbah M. Allam[2]; M.A.F. El-Manilawi[2] and H.F. Amin[1]

[1]Animal Production Research Institute, Agricultural Research Centre, Giza, Egypt.

[2]Animal Production Department, Faculty of Agriculture, Cairo University, Giza, Egypt.

SUMMARY

This study was carried out to investigate the effect of dietary zinc (Zn) supplementation in inorganic (zinc sulfate, $ZnSO_4$) and organic (zinc methionine, Zn-Met) forms at two levels (100 or 200 mg/kg diet) on growth performance, digestibility coefficients and immune response of New Zealand White (NZW) male rabbits. One hundred male NZW rabbit (at 6 weeks of age, 808 ± 11g average body weight) were divided into five homogenous groups. The 1st group was fed basal diet including vitamins & minerals premix which contained 58 mg Zn as a control, the 2nd and the 3rd groups were fed on the same diet supplemented with 100 or 200 mg Zn/kg diet as zinc sulfate (ZnSO4, inorganic form) and the 4th and the 5th groups were fed on the same diet supplemented with 100 or 200 mg Zn/kg diet as zinc methionine (Zn-Met, organic form). Results showed that live body weight at 22 wks of age and total body weight gain of rabbits fed diets supplemented with Zn was significantly ($P<0.01$) higher than those fed diet without supplementation. Rabbits fed diet supplemented with 200 mg Zn-Met/kg diet had significantly heaviest body weight, followed by rabbits fed diet supplemented with 100 mg Zn-Meth/kg diet than groups fed diet supplemented with 200 and 100 mg ZnSO4. Rabbits fed diets supplemented with Zn-Met or ZnSO4 converted feed better than those fed diets without supplementation. Rabbits fed diets supplemented of Zn-Meth at 200 or 100 mg/Kg diets improved nutrients digestibility and nutritive values expressed as TDN and DCP of diets. Zn supplementation (Zn-Meth or $ZnSO_4$) to rabbit diets significantly ($P<0.01$) affected cell-mediated immune response at different hours post injection of phytohemoagglutinins (PHA). Zn from Zn-Meth (200 or 100 mg/kg diets) significantly increased heighten cellular immunity than zinc from $ZnSO_4$. Rabbits fed diets supplemented with Zn (Zn-Meth or $ZnSO_4$) with any levels had significantly ($P<0.01$) higher antibody titer against sheep red blood cell (SRBC) at different weeks post immunization than those fed control diets. Zn-Meth improved significantly antibody titer against SRBC than zinc from $ZnSO_4$. Inclusion 200 mg Zn-Met/kg diet significantly improved antibody titer post three weeks of SRBC injection than 100 mg Zn-Met. It can be concluded that dietary Zn methionine (organic form) at level of 200 mg/kg of rabbit diet improved nutrients digestibility and nutritive values of diets, which could be associated with better growth performance and immune efficiency.

Keywords: *Rabbit, zinc inorganic and organic, growth and immune response.*

INTRODUCTION

Several investigators suggested that zinc is required in rabbits to maintain proper post weaning growth, since supplementation in rabbit diets ranged between 30-107 ppm (Cavalcant and Ferreira, 2000), with suggestion of higher levels for breeders (Mateos and Blas, 1998). The commonly used grains in basal rabbit diets is rich in phytate content that may reduce availability and inhibit absorption of zinc (Baker and Halpin, 1988), since these levels was not adequate to compensate the insufficient zinc in the natural ingredients of the diet. Traditionally, Zn is supplemented in the animal diets as inorganic salt. However, recently the use of organic Zn for animals has gained popularity because of its reported higher bioavailability than inorganic sources (Droke *et al*., 1998).

Zinc is an essential nutrient required in humans and animals for many physiological functions, including immune and antioxidant function and growth (Shay and Mangian, 2000), required for the action of more than 200 metalloenzymes, supports the immune system (Shinde *et al*., 2006) and plays an important role in polymeric organization of macromolecules like DNA and RNA (Garcia-Contreras *et al*., 2011), protein synthesis and cell division (Lukac and Massanyi, 2007).

Therefore, the present experiment was conducted to study the effect of dietary Zn supplementation in inorganic (zinc sulfate, $ZnSO_4$) and organic (zinc methionine, Zn-Meth) forms each at two levels (100 or 200 ppm/kg) on productive performance, digestibility coefficients of nutrients and immune response of New Zealand White rabbit.

MATERIALS AND METHODS

A total of one hundred male New-Zealand White (NZW) rabbits, 6-weeks of age, with an average live body weight of 808±11 gm were randomly divided into five comparable experimental groups (n=20). The 1st group was fed the basal diet including vitamins minerals premix which contained 58 mg zinc (Zn), the 2nd and the 3rd groups were fed on the same diet supplemented with 100 or 200 mg Zn/kg diet as zinc sulfate (0.441 g $ZnSO_4.7H_2O$, inorganic zinc, 287.54 AW/MW and the concentration 22.7%) and the 4th and the 5th groups were fed on the same diet supplemented with 100 or 200 mg zinc methionine (1.0 g Zn-Met super, organic zinc, composition: 10% Zn; 20% methionine and sepiolite to 100%, Super's Diana, S.L., Ctra. Barcelona- Puigcerda, km 17). Rabbits were fed *ad libitum* formulated diets according to NRC (1984). Ingredients and chemical composition of the experimental pelleted diets are shown in Table (1). Water was always freely available. Animals were housed with a constant photoperiod of 16 hours light: 8 hours dark lighting schedule. Rabbits in all treatments were kept under similar management hygienic and environmental conditions during the experimental period.

Table (1). The ingredients and chemical composition of rations fed to rabbits, during the experimental period.

Ingredients
19.0% Clover hay, 35.2% Barley, 26.0% Wheat bran, 14.9% Soybean meal (44% CP), 3.0% Molasses, 1.0% Limestone, 0.3% Sodium chloride, 0.5% Vitamins & Mineral Premix * and 0.1% Cooccidostat.
Chemical analysis (on dry matter basis): 89.2%, Dry matter, 92.92% Organic matter, 16.34% Crude protein, 2.41% Ether extract, 11.86% Crude fiber, 62.31% Nitrogen free extract, 7.08% Ash, 2844 Digestible energy (Kcal/Kg)** and 107.34 zinc (mg/kg)***

*** Calculated according to NRC (1984) for rabbits.*
**** zinc content = 58 mg added from premix.*

Growth Performance:

Rabbits were individually weighed at the beginning of the experiment and at weekly intervals (from 6 -22 weeks of age) to the nearest gram during the experimental period. Feed consumptions were recorded. Body weights gain and feed conversion ratio were calculated.

Evaluation of the Experimental Diets (Digestion Trials):

Fifteen of male adults New Zealand White rabbits were used for five digestion trials that were carried out to determine the digestibility coefficients of nutrients and the feeding value using three comparable selected animals from each group. Animals were kept in individual metabolic cages which allowed a complete separation and collection of feces. The trial lasted 4 days, preliminary period and 3 days collection period. Daily weight of the feed residuals and feces were recorded. The feces were collected daily during the collection period, sprayed with 2% boric acid for trapping any ammonia released from faces. At the end of collection period, representative feces samples (25%of the fresh feces/day) were dried at 60° C for 24 hours (constant weight), then were finely ground and thoroughly mixed to ensure sample uniformity and stored until being analyzed. Representative samples either of diets or dried feces were assigned to determine the dry matter (DM), crude protein (CP), crude fiber (CF), ash and ether extract (EE) according to AOAC (1995). The factor 6.25 was used for calculating CP from nitrogen values. Nitrogen-free extract was obtained by difference as follows: %NFE = 100 – (%Moisture + %Ash + %CP + %EE + %CF).

Immunological Response Efficiency:

1. Cell Mediated Immunity (CMI):

At 13 weeks of age, five representative male rabbits from each group were randomly selected to determine cell mediated immunity (CMI). Fifty µg of Phytohemagglutinin (PHA, dissolved in saline) was injected subcutaneously into a defined area in the right ear in a volume of 0.1 ml while the other ear (left ear) was used as control and injected with 0.1 ml saline. The thicknesses of both ears were measured before, 3, 6, 9, 12, 15, 18, 21 and 24 hours after Phytohemagglutinin (PHA) injection by a clipper (Cotter and Weinner, 1997). The response was calculated as different changes in both ear thickness increasing as following formula: Cell mediated immunity response = changes in right ear thickness increasing after injection with PHA - changes in left ear thickness increasing after injection with saline solution.

***2. Humeral immune response (Antibody production against Sheep Red Blood Cells)*:**

At 13 weeks of age, five representative rabbits from each treatment were intravenously injected with 0.2 ml of 10% suspension of packed Sheep Red Blood Cells (SRBC), a T- cell dependent antigen; McArthur *et al*. (1973). Sheep blood was collected in heparinized tubes. After centrifugation (2000 rpm) for 15 min, cells were washed 3 times in a solution of sodium chloride (9 g/L) and diluted to a 10% (vol/vol) of the same solution. The same procedure was used to collect SRBC from the same sheep to measure the titer of antibodies in rabbits. Blood samples were collected from marginal ear vein of rabbits at one, two, three and four week's post immunization in a dried test tube, kept at room temperature for 30 minutes in horizontal position to allow the blood to clot. The tubes were placed vertically in the refrigerator overnight to obtain a clear serum and kept frozen until tested. Antibody titer against SRBC was determined using the micro titer procedure described by Van der Zijpp and Leenstra (1980). Antibody titers were reported as the log2 of the reciprocal highest dilution giving complete agglutination.

Data were subjected to statistical analysis applying one way ANOVA procedure. The general linear model of SAS (1996) program was used in processing measured parameters. Significant differences among means were tested at ($P<0.05$) by Duncan's multiple range test (Duncan's, 1955).

RESULTS AND DISCUSSION

Growth performance of rabbits:

At 22 weeks of ages, body weight and body weight gain (kg) of male rabbits fed diets supplemented with Zn were significantly ($P<0.01$) higher than those fed diet without supplementation (Table 2). Rabbits fed diet supplemented with 200 mg Zn-Met/kg diet (organic form) had significantly heaviest body weight and body weight gain, followed by rabbits fed diet supplemented with 100 mg Zn-Meth/kg diet than groups fed diet supplemented with 200 or 100 mg $ZnSO_4$/kg diet (inorganic form). Inclusions of 200 mg Zn/kg diet (in the same form) increased total weight gain compared to 100 mg Zn/kg diet. Feed consumption was not significantly affected by Zn addition (Zn-Meth or $ZnSO_4$). Rabbits fed diets supplemented with 200 mg Zn-Meth/kg diet converted feed better than those fed diets supplemented with 100 mg/kg diet. Rabbits fed diet supplemented with 200 mg Zn-Meth or $ZnSO_4$/kg diets had significantly higher living rate values (100%) compared with those fed diet without Zn supplementation (75%). These results agreed with those recorded by Hamed *et al.* (2004), Allam *et al*. (2005) and Selim *et al*. (2012). The significant improvement in body weight of rabbits given the additional Zn may be attributed to sufficient Zn level to plays an important role in polymeric organization of macromolecules like DNA and RNA (Garcia-Contreras *et al*., 2011) which are responsible for the growth and development of skeleton and synthesis of body protein. In addition, zinc is one of trace elements essential for biological functions of all living matter and necessary for growth, appetite, skin integrity and mental activity, Zinc is an essential trace element required for the action of more than 200 metalloenzymes (Barceloux, 1999). Shay and Mangian (2000) found that zinc an essential nutrient is required in humans and animals for many physiological functions, including immune and antioxidant function and growth. Furthermore, may be attributed to that the basal diets were rich in phytate content and the level of 58 mg/kg diet was not adequate to compensate the insufficient zinc in the natural ingredients of the diet. In this respect, Baker & Halpin (1988) showed that soybean meal, wheat bran, cottonseed meal and grains are feed ingredients rich in phytate content and have an antagonistic effect on the availability of zinc. When the diet of rabbits

or swine contains high levels of one or more of these ingredients, the level of added zinc must be elevated to compensate the unavailable zinc that binds with phytate.

The positive effect of zinc from Zn-Meth compared with that from $ZnSO_4$ may be related to the better absorption and the effect of methionine with zinc. Complex Zn with methionine could increase Zn absorption by preventing Zn from forming insoluble complexes in the digestive tract or by facilitating Zn transport across the intestinal mucosa. Edwards and Baker (1999) mentioned that zinc from Zn-Meth was more bioavailable than zinc from $ZnSO_4$. Wedekind *et al.* (1992) used diets with 0, 250, 500 and 750 mg/Kg of Zn coming from $ZnSO_4$, ZnO and Zn-methionine; they observed that the bioavailability of Zn from Zn-Meth was 228% relative to zinc sulfate (100%), whereas zinc oxide had only 61% bioavailability.

Table (2). Growth performance of male New Zealand White rabbits as affected by dietary zinc supplementation level and source (mean±SE).

Treatments	Body weight at 6 wks old (kg)	Body weight at 22 wks old (kg)	Body weight gain (kg)	Daily feed intake (g)	Feed conversion	Live percentage (%)
Control	0.807	2.796^{d}	1.99^{d}	114.12	6.37^{d}	75.00^{b}
$ZnSO_4$-100	0.809	2.956^{c}	2.15^{c}	115.59	6.09^{c}	90.00^{ab}
$ZnSO_4$-200	0.808	3.062^{bc}	2.25^{b}	116.52	5.79^{b}	100.00^{a}
Zn-Meth-100	0.808	3.081^{b}	2.27^{b}	114.09	5.62^{b}	95.00^{a}
Zn-Meth-200	0.810	3.212^{a}	2.40^{a}	113.03	5.27^{a}	100.00^{a}
Stander error	±0.0023	±0.039	±0.036	±1.98	±0.116	-
P<values	0.682	0.01	0.01	0.713	0.01	0.01

$^{a, b, c}$ *Means with different superscripts in the same column, differ significantly (P<0.05).*

Digestibility coefficients and nutritive values:

Rabbits fed diets supplemented with Zn-Meth or $ZnSO_4$ were significantly (P<0.05) higher than the rabbits fed the control diet in DM, OM, CP, CF, EE, NEF digestibility and nutritive values (total digestible nutrients (TDN) and digestible crude protein (DCP), Table 3). Rabbits fed 200 mg Zn-Meth/Kg diets recorded the highest values (P<0.05) of the nutrients digestibility and TDN and DCP values, followed by those fed diet supplemented with Zn-Meth at 100 mg than that fed diets supplemented with 200 or 100 $ZnSO_4$/kg diet. However, the lowest value was recorded by rabbits fed the control diets. These results are in agreements with those reported by Gad Alla (2001) who found that apparent digestibility of DM, OM and EE was significantly (P<0.05) greater due to adding of zinc, but CP, CF and NFE tended to be insignificantly higher than the control group. Hafez *et al.* (2002) also found that rabbit's diets supplemented with Zn recorded higher digestibility of nutrients.

Table (3). Digestible coefficients and nutritive values of NZW male rabbits as affected by dietary level and source zinc of supplementation.

Zinc	Digestible coefficients (%)						Nutritive values (%)	
Supplementation	DM	OM	CP	CF	EE	NFE	TDN	DCP
Control	68 .9^{c}	69.2^{c}	70.2^{c}	40.1^{c}	70.0^{d}	73.9^{c}	65.95^{c}	11.47^{c}
$ZnSO_4$-100	73.9^{b}	74.1^{b}	75.1^{b}	46.3^{b}	77.6^{c}	77.0^{b}	69.86^{b}	12.27^{b}
$ZnSO_4$-200	74.6^{ab}	74.8^{b}	75.7^{ab}	46.9^{b}	78.6^{bc}	77.3^{ab}	70.22^{ab}	12.37^{ab}
Zn-Meth-100	74.8^{ab}	75.7^{ab}	76.6^{ab}	48.9^{a}	80.4^{ab}	78.1^{ab}	71.19^{ab}	12.52^{ab}
Zn-Meth-200	75.5^{a}	76.7^{a}	77.6^{a}	49.6^{a}	81.6^{a}	78.8^{a}	71.94^{a}	12.68^{a}
Stander error	±0.47	±0.54	±0.67	±0.49	±0.75	±0.49	±0.56	±0.13
P<values	0.01	0.01	0.02	0.01	0.01	0.03	0.01	0.04

$^{a, b, c}$ *Means with different superscripts in the same column, differ significantly (P<0.05).*

The improvement of digestion coefficients may be due to Zn supplementation affects protein and carbohydrate metabolism, which found in many highly purified enzymes functioning in protein and carbohydrate digestion (Underwood and Suttle, 1999). Increasing the digestive ability of rabbit by zinc supplementation may be attributed to increasing the activity of some enzymes related to the digestion of

carbohydrates, fats and protein such as amylase, lipase, trypsinogen, chemotrypsinogen and some peptidases, since these enzymes are known to be Zn-dependent enzymes (Banerjee, 1988).

Immunological Response Efficiency:

a. Cell mediated immunity:

Zn supplementation in rabbit diets was significantly (P<0.04 or 0.001) affected cell-mediated immune response at different hours post inoculation of phytohemoagglutinins (PHA) (Table 4). These results are in accordance with those of Luecke *et al.* (1978) who found that zinc has numerous biological roles including the cell mediated immune response. Similarly, Meshreky *et al*. (2006) found that addition of Zn in organic or inorganic form to the rabbit diet significantly improved immune response. In our work rabbits fed diets supplemented with Zn-Meth (200 or 100 mg/kg diets) had changed ear thickness during every phase of ear control test post inoculation than zinc from $ZnSO_4$ (Table 4). These results agreed with those of Ferket and Qureshi (1992) who found that Zn from Zn-Meth has been shown to elevate cellular immunity in poultry over that of Zn from $ZnSO_4$. Kidd *et al.* (1992) stated that zinc methionine increase cellular immunity than Zn from $ZnSO_4$. In the present study ssupplemental 200 mg Zn-Meth/kg diet significantly increased heighten change in ear thickness response to PHA than 100 mg/kg diet post 9 to 24 hr of immunization Table (4). Whereas, inclusion 200 mg $ZnSO_4$/kg diet insignificantly increase changes in ear thickness response to PHA compared to 100 mg $ZnSO_4$. Results showed that rabbits fed diet with100 mg Zn-Meth/kg diet (organic forms) had highest change in ear thickness response to PHA at different hours post injection than those fed diet with 100 or 200 mg $ZnSO_4$/kg diet (inorganic forms).

In respect to the effect of supplemental Zn level, revealed that Kidd *et al.* (1994) reported increased toe web swelling after intradermal injection with PHA in turkeys supplemented with 30 or 45 ppm of Zn from Zn-Met compared to turkeys fed a basal diet containing 130 ppm of Zn.

Table (4). Change in ear thickness in response (mm) to phytohemagglutinin (PHA) at different times (h) post injection of New Zealand White male rabbits as affected by dietary zinc supplementation (level and source).

Zinc Supplementation	Time after injection (h)							
	3	6	9	12	15	18	21	24
Control	0.54^{c}	0.84^{c}	1.10^{d}	0.98^{d}	0.94^{d}	0.78^{d}	0.64^{d}	0.36^{d}
$ZnSO_4$-100	0.60^{bc}	1.34^{b}	1.62^{c}	2.18^{c}	1.76^{c}	1.16^{c}	0.78^{cd}	0.40^{cd}
$ZnSO_4$-200	0.64^{bc}	1.60^{b}	1.98^{bc}	2.30^{c}	1.86^{bc}	1.26^{bc}	0.96^{c}	0.52^{bc}
Zn-Meth-100	0.72^{ab}	1.82^{ab}	2.14^{b}	2.76^{b}	2.12^{b}	1.54^{b}	1.22^{b}	0.62^{b}
Zn-Meth-200	0.92^{a}	1.90^{a}	2.52^{a}	3.42^{a}	2.68^{a}	1.90^{a}	1.54^{a}	0.82^{a}
Stander error	±0.08	±0.12	±0.16	±0.19	±0.13	±0.16	±0.11	±0.07
P<values	0.04	0.01	0.01	<0.001	<0.001	<0.001	0.01	0.02

$^{a, b, c}$ *Means with different superscripts in the same column, differ significantly (P<0.05).*

b. Humoral antibody titer against sheep red blood cell (SRBC):

Zn supplementation were significantly (P<0.01) increased humeral antibody titer against SRBC at different weeks post immunization (Table 5). These results indicated that Zn supplementation have an immunostimulatory effect. Stahl *et al.* (1989) showed a tendency for chicks to express higher haemagglutination titers when fed a diet containing 103 mg Zn/kg compared to those fed the control diet (37 mg Zn/kg). Kidd *et al.* (1996) stated that dietary zinc is required for normal immune function. In addition, Rink and Gabriel (2000) found that zinc is an essential trace element for all organisms and influences the immune system. Shay and Mangian (2000) found that zinc is an essential nutrient required for many physiological functions, including immune and antioxidant function and growth in humans and animals. In the present work, Zn-Meth significantly improved antibody titers than zinc from $ZnSO_4$. These results agreed with Meshreky *et al*. (2006) who found that addition Zinc methionine (organic form) in the rabbit diet significantly increased humeral antibody titer against SRBC compared to zinc sulfate (inorganic form). Previous studies Hahn and Baker (1993) found that organic zinc source such as Zn-Meth was more bioavailable than inorganic zinc source such as $ZnSO_4$. Kidd *et al.* (1994b) stated that zinc methionine may increase mononuclear phagocyte cell function, leading to a possible reduction in a bacterial load by increasing phagocyte potential. Inclusion 200 mg Zn-Meth/kg diet improved

significantly antibody titers three weeks post of SRBC injection than 100 mg Zn-Meth (Table 5). However, inclusion 200 $ZnSO_4$ mg/kg diet of the rabbits insignificantly improved antibody titers to SRBC than 100 mg/kg diet. Results showed also that rabbits fed diet with 100 mg Zn-Meth/kg diet had higher antibody titers against SRBC at different weeks post injection than those fed diet with 100 or 200 mg $ZnSO_4$/kg diet. Shinde *et al*. (2006) found that supplementation of 20-ppm zinc significantly improved the immune response and impact was more prominent with the zn (organic source) compared to $ZnSO_4$ (inorganic source). They added that zinc is an essential trace element required for the action of more than 200 metalloenzymes, supports the immune system.

It could be concluded that, Zn supplementation as organic or in organic forms to the rabbit diet was efficient to promote body weight and feed conversion efficiency and immune response. The best results were achieved with the diet supplemented with 200 mg Zn methionine /kg diet) organic form.

Table (5). Humeral antibody titers against sheep red blood cells (SRBC) of New Zealand White female rabbits at different weeks post immunization as affected by dietary zinc supplementation (means±SE).

Zinc supplementation	Weeks post immunization by SRBC			
	One	Two	Three	Four
Control	3.70^{c}	4.50^{c}	4.20^{d}	3.20^{d}
$ZnSO_4$ -100	5.10^{b}	5.60^{b}	5.40^{c}	4.30^{c}
$ZnSO_4$ -200	5.40^{b}	6.10^{b}	5.90^{bc}	4.80^{bc}
Zn-Meth -100	5.70^{ab}	6.90^{a}	6.20^{b}	5.30^{b}
Zn-Meth -200	6.20^{a}	7.10^{a}	6.90^{a}	6.10^{a}
Stander error (±SE)	±0.37	±0.36	±0.32	±0.32
*P<Value*s	0.01	0.01	0.01	0.01

[a, b, c] Means with different superscripts in the same column differ significantly (P<0.05).

REFERENCES

A.O.A.C. (1995). Association of Official Analytical Chemists. Official Methods of Analysis" 16th Ed. published by the AOAC, Washington, D.C.

Allam, S.M.; Samia Z Meshreky; M.A.F.M. El-Manylawi and H.F. Amin (2005). Effect of dietary protein levels with or without zinc supplementation on: 1. productive performance, carcass traits and economical efficiency of male rabbits. Egypt. J. Rabbit Sci., 15(2):113-129.

Baker, D.H. and K.M. Halpin (1988). Zinc antagonizing effects of fish meal, wheat bran and corn-soybean mixture when added a phytate and fibre-free casein-dextrose diet. Nutrition Research, 8: 213-218.

Banerjee, G.C. (1988). Feeds and Principles of Animal Nutrition. nd2 Edition, Oxford and IBH Publishing Co. PVT Ltd, UK. 636 p.

Barceloux, D.G. (1999). Zinc Toxicol. Clin. Toxicol. 37(2):279-292.

Cavalcante, G.S. and M.W. Ferreira (2000). Bioavailability of dietary zinc sources for fattening rabbits. In the proceeding of 7th World Rabbit Congress. 4-7 July–Valencia, Spain, pp. 255-260.

Cotter, P.F. and J. Weinner (1997). Dietary Bio-Mos modiated Kinetics of the phytohemagglutin wattle reaction in chickens. Poult. Sci., 76 (Suppl.1):111.

Droke, E.A.; M.G.P. Gengelbach and J.W. Spears (1998). Influence of level and source (inorganic vs. organic) of zinc supplementation on immune function in growing lambs. Asian- Aust. J. Anim. Sci., 11:139–144.

Duncan, D.B. (1955). Multiple Ranges and Multiple F-test. Biometrics, 11:1-42.

Edwards, H.M. and D.H. Baker (1999). Bioavailability of zinc in several sources of zinc oxide, zinc sulfate, and zinc metal. J. Anim. Sci., (77), 10:2730-2735.

Ferket, P.R. and M.A. Qureshi (1992). Effect of level of inorganic and organic zinc and manganese on the immune function of turkey toms. Poult. Sci., 71(Suppl.1):60.

Gad Alla, S.A.Z. (2001). Effect of dietary zinc and iodine supplementation on growth performance, apparent digestibility, blood metabolites and reproductive efficiency in Bauscat rabbits. In the proceeding of 2nd Sci. Con. On Animal Production and Health in Semi Arid Area, 4-6 Sep, El Arish,

Egypt, pp. 363-373.
Garcia-Contreras, A.; Y. De Loera; C. García-Artiga; A. Palomo; J.A. Guevara; J. Herrera-Haro; C. López-Fernández; S. Johnston and J. Gosálvez (2011). Elevated dietary intake of Zn-methionate is associated with increased sperm DNA fragmentation in the boar. Reprod Toxicol., 31(4):570-573.
Hafez, S.I.; Nadia. El-Awady.; T.A.A. Deraz and M.H.M. Yacout (2002). Response of supplemental some mineral elements in rabbits diets on digestibility nutritional balances and feed efficiency. J. Agric. Sci. Mansoura Univ., 27(3):1393-1403.
Hahn, J.D. and D.H. Baker (1993). Growth and plasma zinc responses of young pigs fed pharmacological levels of zinc. J. Anim. Sci., 71:3020-3024.
Hamed, R.S.; M.E. Omara, and Kh. Amber (2004). A comparison studies of zinc and copper sulphate requirements of the New Zealand White and Baladi Black rabbits. Egypt. Poult. Sci., 24 (III):597-611.
Kidd, M.T.; N.B. Anthony and S.R. Lee (1992). Progeny performance when dams and chicks are fed supplemental zinc. Poult. Sci., 71:1201-1206.
Kidd, M.T.; P.R. Ferket and M.A. Qureshi (1996). Zinc metabolism with special reference to its role in immunity. World Poul. Sci., 52:309–324.
Kidd, M.T.; M.A. Qureshi; P.R. Ferket and L.N. Thomas (1994). Dietary zinc methionine enhances mononuclear-phagocytic function in young turkeys. Biol. Trace Elem. Res., 42:217–229.
Luecke, R.W.; C.E. Simonel and D.J. Ferker (1978). The effect of restricted dietary intake on the antibody mediated response of the zinc deficient A/J mouse. J. Nutr., 8: 881.
Lukac, N. and P. Massanyi (2007). Effects of trace elements on the immune system. Epidemiol Mikrobiol Imunol, 56:3-9.
Mateos, G.G. and C. Blas (1998). Minerals, vitamins and additives. In: Blas, C.; Wiseman, J. The nutrition of the rabbit. London: CABI Publishing, 9:145-175.
McArther, W.P.; D.G. Gilmour and G.J. Thorbecke (1973). Immunocompetent cells in the chicken. II. Synergism between thymus cells and either bone marrow or bursal cells in the humoral immune respose to sheep erythrocytes. Cellular Immunology, 8:103-111.
Meshreky, Samia, Z.; S.M. Allam; M.A.F.M. El-Manylawi and H. Farouk. (2006). Effect of dietary protein levels with or without zinc supplementation: 2. some blood constituents and immune response efficiency of growing rabbits. Egypt. J. Rabbit Sci., 16 (2): 277- 296.
NRC (1984). National Research council, Nutrient requirements of Domestic. Nutrient Requirements of Rabbits. Second Revised Edition, National Academy of Sci., Washington D.C, USA.
Rink, L. and P. Gabriel (2000). Zinc-altered immune function and cytokine production. J. Nutr. 130:1407S-1411.
SAS (1996). Sas User,s Guide; Statistics, Ver. 6. 04th Ed., Sas Institute, Inc., Cary, Nc.
Selim, Nessrin, A.; A. Abdel-Khalek and Sawsan, M. Gad (2012). Effect of supplemental zinc, magnesium or iron on performance and some physiological traits of growing rabbits. Asian J. Poult. Sci., 6(1):23-30.
Shay, N.F. and H.F. Mangian (2000). Neurobiology of zinc-influenced eating behavior. J. Nutr., 130 (55 suppl):14935-95.
Shinde, P.; R.S. Dass; A.K. Garg; V.K. Chaturvedi and R. Kumar (2006). Effect of zinc supplementation from different sources on growth, nutrient digestibility, blood metabolic profile and immune response of male guines. Biol. Trace Elem. Res., 112(3):247-262.
Stahl, J.L.; J.L. Greger and M.E. Cook (1989). Zinc, copper and iron utilization by chicks fed various concentrations of zinc. Br. Poult. Sci., 30:123-134.
Underwood, E.J. and N.F. Suttle (1999). The mineral nutrition of livestock. 3rd. Edition. CABI Publishing, New York.pp1-614.
Van der Zijpp, A. J. and F.R. Leenstra (1980). Genetic analysis of the humoral immune response of white Leghorn chicks. Poult. Sci., 59(9):1363–1369.
Wedekind, K.J.; A.E. Hortin, and D.H. Baker (1992). Methodology for assessing zinc bioavailability: efficacy estimates for zinc-methionine, zinc sulphate and zinc oxide. J. Anim. Sci., 70 (1):178-187.

تأثير مصدر و مستوى الزنك المضاف على أداء النمو، كفاءه الهضم و الأستجابه المناعيه للأرانب النيوزيلاندى الأبيض

ساميه زكريا مشرقى[1]، صباح محمود علام[2]، محمد أحمد المنيلاوى[2]، حمدى أمين[1]

[1]معهد بحوث الأنتاج الحيوانى، مركز البحوث الزراعيه، جيزه-مصر.

[2]قسم الأنتاج الحيوانى،كليه الزراعه، جامعه القاهره، جيزه، مصر.

أجريت هذه الدراسة لمعرفة تأثير التغذيه بالزنك المضاف في صوره غير عضوية (كبريتات الزنك، ZnSO4) والعضوية (الزنك ميثايونين، Zn-Met) على مستويين (100 أو 200 ملغم / كغم علف) على أداء النمو ، معاملات الهضم واستجابة جهاز المناعة لذكور الأرانب النيوزيلندى الأبيض. تم تقسيم مائة من الذكور (عمر 6 أسابيع ، متوسط وزن الجسم 808 ± 11جم) إلى خمس مجموعات متجانسة. تم تغذية المجموعة الأولى على العليقه الأساسيه مشتمله على خلطة البرمكس من الفيتامينات والمعادن التي تحتوي على 58 ملغ الزنك كمجموعه ضابطه، غذيت المجموعة الثانيه و الثالثه على نفس العليقه مضافا لها 100 أو 200 ملغ الزنك / كغ علف كبريتات الزنك (ZnSO4، شكل غير عضوي) وغذيت المجموعة الرابعه و الخامسه على نفس العليقه مضافا لها 100 أو 200 ملغ الزنك / كغ علف من الزنك ميثيونين (الزنك ميثيونين، شكل عضوي). أظهرت النتائج أن وزن الجسم الحي عند 22 أسبوعا من العمر، ومجموع الزيادة في وزن الجسم من الأرانب المغذاه على عليقه مضاف لها الزنك كان أعلى معنويا (على مستوى 1%) من التي غذيت على عليقه دون أضافه. الأرانب المغذاه على عليقه مضاف لها 200 ملغ الزنك ميثايونين / كجم عليقة كان إلى حد كبير أثقل فى وزن الجسم، تليها الأرانب التى غذيت على عليقه مضاف لها 100 ملغ الزنك ميثايونين / كجم عليقة مقارنه بالمجموعات المغذاه على عليقه مضاف لها 200 أو 100 ملغ كبريتات زنك. الأرانب التى غذيت على عليقه مضاف لها زنك ميثايونين أو كبريتات زنك حولت غذاء أفضل من تلك التى غذيت على عليقه بدون أضافه. حسنت الأرانب التى غذيت على عليقه مضاف لها زنك ميثايونين 200 أو 100 ملغ / كغ عليقه عمليه هضم الغذاء و مجموع المواد الغذائية القابلة للهضم (TDN) وهضم البروتين الخام (DCP) للعليقه. أضافه الزنك (الزنك ميثايونين أو كبريتات زنك) إلى علائق الأرانب أثر معنويا (على مستوى 1%) على استجابة الخلايا المناعية في الساعات المختلفة بعد الحقن بالفيتوهيمواجلوتنين (PHA). زاد معنويا الزنك من الزنك ميثايونين (200 أو 100 ملغ / كغ عليقه) أرتفاع المناعة الخلوية مقارنه ب الزنك من كبريتات الزنك. الأرانب التى غذيت على عليقه مضاف لها زنك (زنك ميثايونين أو كبريتات زنك) مع أي مستويات كانت أعلى معنويا (على مستوى 1%) فى عيار الأجسام المضادة ضد خلية الدم الحمراء للأغنام في الأسابيع المختلفة بعد التحصين مقارنه بتلك التى غذيت على العليقه الضابطه. حسن معنويا الزنك ميثايونين التتر ضد خلية الدم الحمراء للأغنام عن الزنك من كبريتات الزنك. إدراج 200 ملغ الزنك ميثايونين/ كجم عليقة حسن معنويا في عيار الأجسام المضادة ضد خلية الدم الحمراء للأغنام بعد ثلاثة أسابيع من الحقن عن 100 ملغ الزنك ميثايونين. ويمكن أن نخلص إلى أن التغذيه على الزنك ميثايونين (الشكل العضوي) بمستوى 200 ملغم / كغم فى عليقه الأرنب حسن هضم المواد الغذائية والقيمة الغذائية للعليقة و التي يمكن أن تتوافق مع أداء نمو أفضل وكفاءة المناعة.