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Effect of Supplemental Zinc, Magnesium or Iron on Performance and Some Physiological Traits of Growing Rabbits

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ABSTRACT

The objective of this study was to investigate response of growing rabbits to added levels of zinc, magnesium or iron. Three growth experiments were carried out using 150 NZW rabbits of 5 weeks old to study the effect of different supplemental levels of zinc, magnesium or iron on growth performance and some carcass traits. Concentrations of these elements in blood plasma, urine and/or hair or bone were measured. In each experiment, 50 rabbits were allocated individually up to the 13th week of age to one of five experimental groups. In the 1st experiment five levels of zinc (as zinc oxide) being 0, 50, 100, 200 or 400 Zn mg kg^{-1} diet were examined. In the 2nd experiment Mg (as magnesium oxide) was used by levels of 0, 400, 600, 800 or 1000 Mg mg kg^{-1} diet. Iron (as ferrous sulphate) was used in to provide levels of 0, 25, 50, 75 or 100 Fe mg kg^{-1} diet in the 3rd experiment. The results showed that supplementing Zn by levels of 100 or 200 mg kg^{-1} diet significantly ($p<0.05$) improved live weight gain and feed conversion ratio compared to the higher level of 400 mg kg^{-1} diet. Dietary Zn level had no significant effect upon feed intake, carcass traits or Zn concentration in plasma, hair or urine. Supplementing 400 up to 1000 Mg mg kg^{-1} diet significantly ($p<0.05$) improved feed conversion ratio of the diet and enhanced ($p>0.05$) live weight gain of the rabbits. It did significantly ($p<0.05$) affect feed intake and liver weight (% of body weight). Mg supplementation showed no significant effect on kidney weight and concentrations of Mg in plasma, bone or urine. Supplementing Fe had no further effect on rabbit studied criteria, except for the plasma total iron binding capacity that significantly decreased with supplementing 75 Fe mg kg^{-1} diet compared with the other treatments. It could be conclude that growing rabbit is tolerable to excessive dietary doses of the Zn, Mg or Fe. Also, it is quite clear that the growing rabbit responded positively to 100 mg supplemental Zn kg^{-1} diet, in terms of significant improvement in live body weight gain and feed conversion ratio. Also, a supplemental Mg in the rate of 400 mg kg^{-1} diet tended to improve live body weight gain and significantly improved feed conversion ratio of the rabbit. While, supplementing Fe above the recommended level (25 mg kg^{-1} diet) had no added value for growing rabbits.

Key words: Zinc, magnesium, iron, physiological traits, rabbits

INTRODUCTION

The domestic or European rabbit (*O. cuniculus*) is one of the animal species that has the highest capacity to produce meat in relation to its weight. Furthermore, rabbits generating up to 40 offspring per year due to the short periods of gestation and lactation which is much higher than the 0.8 and 1.4 offspring per year for bovine and ovine cattle, respectively (Valenzuela *et al*., 2011).

Most published articles stressed on the morphologic and physiological characteristics of the rabbit's carcass (Fernandez and Fraga, 1996) or genetic improvement (Larzul *et al*., 2005).

Food composition tables are usually generated by each country, thus it is common that values for iron (Fe), zinc (Zn) and copper (Cu) differ among these, in general due to different food processing and laboratory assessment techniques. Furthermore, FAO and WHO have recognized that the generation, compilation and dissemination of data on the mineral composition of foods are a priority (Institute of Medicine, Food and Nutrition Board, 2001). There is scarce information on the mineral requirements and it becomes more problematic given that the available information is controversial.

Over the last decades, studies on the response of growing rabbits to dietary macro and micro elements have shown controversial results. Lang (1981) pointed out that a few of works have been developed in order to determine the optimal inclusion rate of minerals in rabbit diets and data in the literature concerning the recommendations lead to discrepancies. About more than two decades later, Mateos and de Blas (1998) came out to the same conclusion. The scientific information on the requirements of highly productive rabbits for minerals published is very limited for some macro elements and nil for the majority of the oligo-elements. Therefore, most of the information gathered is based on old data and on practical figures obtained under commercial conditions. The current situation has not substantially changed from those previously stated.

Zinc supplementation has various beneficial effects on body functions, such as acid base balance, nutrient metabolism and immunity protection (Banerjee, 1988). Zinc acts as activator for many enzymes and hormones (Riordan and Vallee, 1976). The proposed Zn requirements vary from 30-60 ppm with higher values for breeders. These values are used for rabbits fed practical diets. However, there are no trials have been conducted to quantify the actual requirements (Mateos and de Blas, 1998) and possible further improvement in performance associated with extra inclusion beyond recommendation.

The importance of Magnesium rather being is a major bone component, it plays an effective role in many energy metabolism reactions. The excess of Mg is eliminated through the urine. The requirements in Mg for growing rabbits vary from 0.3-0.4 g kg^{-1} diet (NRC, 1977) to 3 g kg^{-1} diet (Lebas, 1990). Evans *et al*. (1983a, b) determined Mg requirements for fryer rabbits and found that 3.4 Mg g kg^{-1} diet fulfilled requirements. Diets contained 1.7 Mg g kg^{-1} was insufficient. The content and apparent digestibility of Mg in most raw materials is high and the need to add extra Mg to commercial rabbit diets has not been established (Lebas, 1990).

Iron, in addition to having other functions, is a major constituent of the pigments and enzymes involved in oxygen transport and metabolism (Mateos and de Blas, 1998). Limit research work on growing rabbits had been carried out to study the response to supplemental Fe.

The current research was designed to study response of growing rabbits to different supplemental levels of Zn, Mg or Fe on growth performance and some carcass traits and concentrations of these elements on blood plasma, urine, hair, or bone.

MATERIALS AND METHODS

Animals, feed and allocation: A total number of 150 NZW rabbits of 5 weeks old were distributed among three experiments (50 rabbits, each). Rabbits were housed individually in galvanized wired cages under the same managerial hygienic and environmental conditions up to the 13th week of age. A basal diet was formulated to cover the nutrient requirements recommended by the NRC (1977). Formulation and nutrient composition of the basal diet are presented in

Table 1: Formulation and calculated chemical composition of the basal diet

Item	Percentage (%)
Ingredients	
Wheat bran	25.5
barley	23.0
soybean meal	21.5
wheat straw	19.5
yellow corn	7.5
Limestone	1.5
Di-calcium phosphate	0.5
NaCl	0.3
Vitamins & minerals premix*	0.3
Dl-Methionine	0.2
Anti-coccidia	0.1
Anti-fungal	0.1
Total	100.0
Chemical composition	
Dray matter	89.00
Crude protein	17.06
Digestible energy (kcal kg^{-1})	2605.00
Crude fiber	13.12
Calcium	0.91
Phosphorus	0.64
Lysine	0.87
Methionine+cystine	0.69

*Supplied per 1 kg of diet: vit. A: 12000 IU, vit D3: 2200 IU, vit. E: 13.4 mg, vit. K3: 2.0 mg, vit. B1: 1.0 mg, vit. B2: 4.0 mg, vit. B6: 1.5 mg, vit. B12: 0.0010 mg, vit. PP: 6.7 mg, vit. B5: 6.67 mg, vit. B8: 0.07 mg, vit. B9: 1.67 mg, Choline chloride: 400 mg, Mg: 133.4 mg, Fe: 25.0 mg, Zn: 22.3 mg, Mn: 10.0 mg, Cu: 1.67 mg, I: 0.25 mg, and Se: 0.033 mg

Table 1. In the 1st experiment different levels of zinc oxide were added to the basal diet to provide supplemental Zn levels being 0, 50, 100, 200 or 400 mg kg^{-1} diet. In the 2nd experiment magnesium oxide was added to the basal diet to provide supplemental Mg levels being 0, 400, 600, 800 or 1000 mg kg^{-1} diet. In the 3rd experiment ferrous sulphate was added to the basal diet to provide supplemental Fe levels being 0, 25, 50, 75 or 100 mg kg^{-1} diet. Rabbits were allowed for access to the experimental diets and water throughout the experimental period. At the end of the experiments body weight gain, feed intake and feed conversion ratio were recorded.

Carcass traits: Three rabbits of each treatment were fasted for 12 hours and then slaughtered; fur was immediately loosened and peeled. Hot carcass, head, liver, kidneys and heart, altogether were considered the dressing. Dressing, liver and kidneys weights were proportioned to the live weight upon slaughtering.

Elements determination: At the end of the growth experiments, three rabbits of each dietary treatment were assigned to Zn, Mg or Fe determination. In exp 1, Zn was determined in blood plasma, hair and urine according to the described method of Makino *et al*. (1982). In exp 2, Mg was determined in blood plasma, bone and urine according to the method of Tietz (1983). In exp 3, Total Iron Binding Capacity (TIBC) in blood plasma was determined according to Fairbanks and Klee, (1994). Iron in blood plasma and urine were determined according to Dreux (1977).

Statistical analysis: Data of each experiment were statistically analyzed for one-way analysis of variance using the general liner model of SAS (1990). Significant differences among treatment mean were separated by Duncan's new multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Results in Table 2 show the response of studied variables to different supplemental dietary Zn levels. Dietary Zn levels did significantly affect ($p<0.05$) body weight gain and feed conversion ratio. Adding Zn by levels of 50, 100 or 200 mg kg^{-1} diet significantly improved body weight gain and feed conversion ratio. Increasing the supplemental Zn level to 400 mg kg^{-1} diet resulted in significant ($p<0.05$) less body weight gain and worse value of feed conversion ratio compared to the control and the other supplemented levels. Dietary Zn levels did not significantly affect feed intake, carcass traits; dressing%, liver%, kidneys% and Zn concentration in blood plasma, hair and urine. However, addition of Zn by levels of 50, 100 or 200 mg kg^{-1} diet showed numerically higher liver and kidney weights (as % of live weight) compared to those fed the control of no Zn supplementation or those fed the highest level of supplementation (400 mg kg^{-1}). Inconsistent trends were observed on the concentration of Zn in blood plasma, hair and urine as affected by dietary Zn supplementation level.

These results indicated that rabbits are efficient in using extra dietary Zn levels beyond recommendations and proved the results of earlier studies. Abd El-Rahim *et al.* (1995) found that dietary supplementation of rabbit diet with 170 Zn mg kg^{-1} diet improved live body gain and feed conversion ratio. Ayyat and Marai (2000) reported that supplementing rabbit diets with 100, 200 or 300 Zn mg kg^{-1} significantly ($p<0.05$) increased live weight gains, but had no effect on feed intake, feed conversion ratio or dressing yield of the rabbits compared with the control or those fed 400 Zn mg kg^{-1} supplemented diet. In contrary, Al-Khalifa (2006) reported that supplemental dietary Zn by levels of 50, 100, or 200 ppm had no significant effect on live weight gain, feed conversion ratio, or dressing percentage of rabbits. The obtained data suggest that live weight gain

Table 2: Effect of dietary supplemental zinc levels on performance, carcass criteria and zinc concentration in plasma, hair and urine of growing rabbits

	Supplemental Zn (mg kg^{-1} diet)						
Variable	Control*	50	100	200	400	Pooled SE	p-value
Growth performance							
IBW (g)	480.00	492.00	503.00	496.00	510.00	9.70	0.901
BWG (g)	1226.00^{ab}	1313.00^{a}	1377.00^{a}	1336.00^{a}	1145.00^{b}	25.70	0.026
FI (g)	4633.00	4829.00	4729.00	4734.00	4671.00	55.00	0.850
FCR	3.85^{ab}	3.70^{ab}	3.44^{b}	3.56^{b}	4.10^{a}	0.07	0.034
Carcass criteria							
Dressing %	61.30	62.00	62.90	65.40	62.30	0.570	0.179
Liver %	2.81	3.49	3.53	3.12	2.97	0.127	0.298
Kidneys %	0.71	0.78	0.81	0.81	0.70	0.026	0.581
Zinc concentration							
Plasma (mg dL^{-1})	131.00	114.00	180.00	147.00	108.00	14.100	0.520
Hair (mg dL^{-1})	75.00	83.00	58.00	58.00	67.00	5.510	0.588
Urine (mg dL^{-1})	399.00	298.00	242.00	366.00	399.00	21.390	0.289

*The control diet contained Zn: 22.3 mg kg^{-1} diet, IBW: Initial body weight, BWG: Body weight gain, FI: Feed intake, FCR: Feed conversion ratio, Means with different superscripts in the same row differ significantly ($p<0.05$)

and feed conversion ratio of growing rabbits could be improved by 12.3 and 10.6%, respectively, with supplementing the diet with 100 Zn mg kg^{-1} over the content provided by the control diet (10 mg kg^{-1} diet). On the same regard, Hossain and Bertechini (1993) reported that the dietary requirement of Zn for maximum rabbit growth was established at 90 mg kg^{-1} diet. Ayyat and Marai (2000) attributed the beneficial effect of supplemental Zn on live weight gain of rabbits that high level of Zn could compensate for dietary Zn complexes with phytic acid of the feed ingredients. Moreover, Baker and Halpin (1988) indicated that soybean meal and wheat bran which are major ingredients of rabbit diets are rich in phytate content that has an antagonistic effect against available Zn.

The results in Table 3 indicate the effect of supplemental Mg levels on the performance and the other measured traits. Although, pronounced improvement in weight gain was reached for rabbits fed the supplemental Mg diets compared to the control rabbits that fed non supplemented diet, no significant differences were detected on body weight gain among treatments. This may be due to variations among individuals within groups. The increases in live body weight gain ranged from 9.49% (1000 mg kg^{-1} diet) to 19.22% (400 mg kg^{-1} diet) over the control group. On the other hand, significant differences ($p<0.05$) were obtained in feed intake and feed conversion ratio between treatments. Rabbits fed 600 Mg mg supplemented diets gave the best value of feed conversion ratio. This means that such group utilized feed more efficiently than the control rabbits and the other groups.

Among the measured treats liver weight (% of live body weight) were significantly ($p<0.05$) affected by dietary Mg levels. Rabbits fed 800 Mg mg kg^{-1} diet showed the highest treats liver weight among treatments. However, inconsistent trend was observed. No significant effects were detected on dressing and kidney weights as a result of Mg supplementation. Other studied traits were not significantly affected by dietary Mg levels. Also, such supplementation did not affect Mg concentrations in plasma, bone and urine.

The published results on the effect of supplemental Mg on rabbit growth performance are scarce. Abdel-Khalek (1999) reported that feeding a diet contained 1% MgO had a favorable effect on growth performance of rabbits grown under summer season conditions while, Robinson *et al.* (1988) found that feeding growing rabbits on a diet with 2% MgO increased the final live weight

Table 3: Effect of dietary supplemental magnesium levels on performance, carcass criteria and magnesium concentration in plasma, bone and urine of growing rabbits

	Supplemental Mg (mg kg^{-1} diet)						
Variable	Control*	400	600	800	1000	Pooled SE	p-value
IBW (g)	482.00	514.00	494.00	476.00	515.00	10.10	0.652
BWG (g)	1212.00	1445.00	1429.00	1366.00	1327.00	29.60	0.084
FI (g)	4740.00^{ab}	5053.00^{a}	4590.00^{b}	4583.00^{b}	4579.00^{b}	59.40	0.049
FCR	3.96^{a}	3.51^{b}	3.22^{b}	3.40^{b}	3.50^{b}	0.070	0.012
Dressing %	62.00	65.20	62.80	63.70	62.60	0.440	0.167
Liver %	2.85^{b}	2.95^{b}	3.48^{ab}	3.99^{a}	3.41^{ab}	0.134	0.018
Kidneys %	0.79	0.89	0.77	0.91	0.89	0.026	0.309
Mg plasma (mg dL^{-1})	1.18	1.83	2.13	1.68	1.21	0.179	0.425
Mg bone (mg dL^{-1})	16.48	13.99	13.45	17.02	15.96	0.604	0.294
Mg urine (mg dL^{-1})	7.33	9.41	7.63	7.73	9.07	0.572	0.784

*The control diet contained Mg: 133.4 mg kg^{-1}, IBW: Initial body weight, BWG: Body weight gain, FI: Feed intake, FCR: Feed conversion ratio, Means with different superscripts in the same row differ significantly at $p<0.05$

Table 4: Effect of dietary supplemental iron levels on performance carcass criteria and iron concentration in plasma and urine and total iron binding capacity of growing rabbits

	Supplemental Fe (mg kg^{-1} diet)						
Variable	Control*	25	50	75	100	Pooled SE	p-value
IBW (g)	478.00	509.00	502.00	507.00	513.00	17.55	0.9090
BWG (g)	1262.00	1266.00	1251.00	1231.00	1286.00	26.30	0.8940
FI (g)	4679.00	4329.00	4719.00	4571.00	4456.00	56.30	0.8940
FCR	3.74	3.42	3.85	3.76	3.51	0.07	0.1820
Dressing %	63.10	61.00	60.30	63.00	62.60	0.99	0.8900
Liver %	2.96	3.02	3.30	3.07	3.59	0.11	0.3880
Kidneys %	0.72	0.88	0.75	0.81	0.94	0.03	0.2880
Fe plasma (mg dL^{-1})	167.00	145.00	149.00	137.00	159.00	9.10	0.8880
Fe plasma TIBC** (mg dL^{-1})	270.00^{a}	231.00^{ab}	223.00^{ab}	181.00^{b}	252.00^{a}	10.90	0.0227
Fe urine(mg dL^{-1})	434.00	328.00	395.00	353.00	278.00	22.40	0.2530

*The control diet contained Fe: 25 mg kg^{-1}, IBW: Initial body weight, BWG: Body weight gain, FI: Feed intake, FCR: Feed conversion ratio, **Total iron binding capacity

gain by 3.7%. It seems that growing rabbits are tolerant to high levels of supplemental Mg. In the present study, there was a gradual decrease in live weight gain with increasing the supplemental Mg level beyond 400 mg kg^{-1} diet. Also, it is worth noting that in the current study that supplemental Mg did not have any negative impact on Mg metabolism, as seen with the data concerning Mg concentrations in plasma, bone and urine, where no significant differences were observed between groups for the studied variables.

Data presented in Table 4 indicated that growth performance, carcass traits and Mg concentration in plasma and urine were not significantly affected by added Fe levels.

Total iron binding capacity (TIBC) was significantly ($p<0.05$) affected by studied Fe levels, with inconsistent trend. The control rabbits fed no Fe supplement diet recorded the highest value of TIBC being 270 mg dL^{-1}. The lowest value being 181 mg dL^{-1} was recorded for those fed 75 Fe mg kg^{-1} diet. There is a lake on the published data regarding the effect of dietary iron level on performance of growing rabbits which make it difficult to comment on the obtained data. It seems that the rabbit needs as little as iron in the diet to fulfill its dietary requirements. Brock (1994) stated that iron is a nutrient related to health and immunity for all livestock. Kamphues *et al.* (1992) related the improvement in growth rate of suckling pigs with supplemental iron to the lower incidence of diarrhea. In the current study, the rabbits had been in good health status throughout the experimental term and no health complaint was reported. As we did not find in the literature results of similar studies in rabbits, no comparisons are possible.

CONCLUSION

However, it could be conclude that growing rabbit is tolerable to excessive dietary doses of the macro Zn, Mg or Fe elements. Also, it is quite clear that the growing rabbit responded positively to 100 mg supplemental Zn kg^{-1} diet, in terms of significant improvement in live body weight gain and feed conversion ratio. Also, a supplemental Mg in the rate of 400 mg kg^{-1} diet tended to improve live body weight gain and significantly improved feed conversion ratio of the rabbit. While, supplementing Fe above the recommended level (25 mg kg^{-1} diet) had no added value for growing rabbits.

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