THE EFFECT OF DIETARY SUPPLEMENTATION ZINC SOURCE AND LEVEL ON GROWING PERFORMANCE, MINERAL DEPOSITION AND MEAT QUALITY

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ABSTRACT

Zinc is involved in the normal and adequate growing of animals. Therefore, it is assumed that zinc supplementation improves the characteristics of canal and meat of New Zealand White rabbits (NZW). The objective was to compare the effect of two zinc sources on growing, meat quality, and muscle deposition in NZW rabbits during the fattening stage. 100 35-day-old NZW rabbits were considered. Treatments consisted of: T1= A basal diet (BD) zinc-free, T2= BD+ 25 ppm Zn ($ZnSO_4$), T3= BD+ 75 ppm Zn ($ZnSO_4$), T4= BD+ 25 ppm Zn (Zn-Methionine) y T5= BD+ 75 ppm Zn (Zn-Methionine). A completely Random Design was used in accordance with factorial treatments 2x2+1 (2 sources x 2 level of zinc + control). Test period was 30 days. Variables considered were growth and meat quality; Zinc content was determined in serum, liver, loin and leg in each test unit. Results showed no differences in growth characteristics; in loin, L*, B* and collagen content in the organic source were affected. No significant differences were found (P>0.05) regarding the source of zinc, but there were differences between zinc levels (P=0.02), favoring the level of supplementation 25 ppm. No differences (P>0.05) were found in leg between sources and zinc levels. The importance of determining a zinc level that improves its deposition in rabbit meat can help meet Zn´s daily requirements in adults.

Key words: mineral deposition, loin.

INTRODUCTION

Zinc is an essential trace mineral for life (Kambe et al., 2015); it acts as a cofactor in more than 300 enzymes (El-hack et al., 2017) and as a transcription factor (Xu et al., 2017). Zinc also is involved in the normal growing of animals (Sloup et al., 2017; Meshreky et al., 2015), their reproduction (Oliveira et al., 2004), DNA synthesis, cell division, gene expression (Cui et al., 2017), and immune protection (Yan et al., 2017; Liu et al., 2011). However, the amounts of zinc in non-ruminants are affected by interaction with anti-nutritional factors such as phytic acid (Bao and Choct, 2009; Saleh et al., 2018), and other plant ingredients in their diet, decreasing the availability and absorption of zinc on gastrointestinal tract (Salim et al., 2012) in broilers (Zakaria et al., 2017), rabbits (Meshreky et al., 2015) and pigs (Xu et al., 2017), becoming a constraint in breeding for commercial purposes.

Studies in zinc-supplemented rabbits have found weight improvement of pregnant rabbits and litter at birth (Alikwe et al., 2011; Cavalcante y Ferreira, 2000); in males supplemented with zinc oxide, an improvement in semen characteristics has been found (Oliveira et al., 2004). Organic zinc is considered an alternative source, due to its better absorption and utilization. A supplement of 80 mg Zn kg^{-1} in Zn-lactate form decreased incidence of diarrhea in rabbits for fattening (Yan et al., 2017). The inclusion of 100 mg kg^{-1} of zinc in Glycinoplex-Zn or Bioplex-Zn forms improved digestibility (Na, K, Fe, Mn and Zn), and in meat it has increased its cholesterol level, water holding capacity and energy value (kJ 100 g^{-1}) in the *longissimus dorsi* muscle (Chrastinová et al., 2016; Chrastinová et al., 2015). Rabbits that received a 200 mg zinc kg^{-1} supplementation in form of

Zinc-Methionine had higher digestibility coefficient, weight gaining and immune response (Meshreky et al., 2015). However, studies on meat quality, considering different concentrations of zinc supplementation are limited. Therefore, the objective of this study was to evaluate the effect of zinc sources and levels in growing performance, meat quality, and zinc content in muscle, serum, and liver of New Zealand White rabbits.

MATERIALS AND METHODS

Animals: A total of one hundred (100 NZW) from both genders and 35 days of age. They were randomly assigned to one of five treatments. Rabbits were housed individually in stainless steel mesh cages; 5-day adaptation period was considered, followed by a 30-day test period.

Diet: Basal diet (DB) was prepared (Table 1), based on the requirements recommended by De Blas and Wiseman 2010, varying the source and level of zinc: T1= (DB) without zinc supplementation, only with the input of the ingredients (25 mg kg^{-1}), T2= DB+25 mg kg^{-1} with zinc as $ZnSO_4$, T3= DB+75 mg kg^{-1} Zn as $ZnSO_4$, T4= DB+25 mg kg^{-1} Zn as Zn-Methionine y T5= DB+75 mg kg^{-1} Zn as Zn-Methionine. Rabbits were fed by pelletized diets (3.5 mm diameter) and unlimited amount of water supply.

Table 1. Composition of the basal diet for rabbits in the fattening stage

Ingredient composition	Amount %		
Dehydrated Alfalfa meal	48.70	Sodium bicarbonate	0.37
Wheat bran	30.00	Bicalcium phosphate	0.20
Tejocote meal (Crataegus mexicana)	10.00	Anti-coccidial	0.10
Corn	7.50	Chemical composition	Content
Sugar cane	1.00	Digestible Energy (kcal/kg)	2185
Colza oil	1.00	Crude Protein (%)	15.72
Vitamin mixture*	0.10	Crude Fiber (%)	15.67
Mineral mixture**	0.30	Dry matter (%)	89.56
L-Lysine -98%	0.20	Ether Extract	3.83
DL-Methionine-99%	0.18	Ash	9.55
Sodium chloride (NaCl)	0.10	FAD	22.31
L-Threonine	0.10	FND	32.94
L-Tryptophan	0.15	Zinc (mg. kg^{-1})	25.5

*Vitamins; A 10000 UI, D_3 1000, E 20.00 mg, K_3 1.00, B_1 1.00, B_2 3.00, B_6 1.00, niacin 28.00, pantothenic acid 10.00, folic acid 0.20, biotin 0.1, Colin 250 and B_{12} .01 mg/kg diet
** Cu 4, I 0.25, Fe 15, Mn 5, Co 0.10 and Se 0.1 mg/kg diet

Study and variable analysis: Weight gaining, food intake, and food conversion were determined. After the test, all the animals were slaughtered in the institutional slaughterhouse, blood samples were collected in vacutainer tubes with no anticoagulant to facilitate serum separation. Serum was stored at -20°C until analysis. Samples were obtained from: liver, loin, and legs immediately after slaughter from each test unit and stored in Ziploc® bags at -80°C until and protein analysis, fat, moisture, collagen and water holding capacity was determined. Color and pH were measured 10 minutes after slaughter.

Experimental design: Test was conducted using a total of 100 rabbits, in a completely randomized design involving a 2x2+1 factorial arrangement of treatments (2 source x 2 zinc levels + group control) sources of zinc were: zinc sulfate monohydrate ($ZnSO_4.H_2O$ with 36.43% zinc) and zinc methionine (12% zinc). Zinc levels were 25 and 75 ppm Zn.

Statistical analysis: Once the values were obtained, they were expressed as average standard error, with the statistical package SAS (v.9.4). Data were analyzed using two-way ANOVA, and GLM

procedure. The model includes the main zinc source effects, the level of zinc supplemented and their interaction. Significant differences between the means were tested at one ($p<0.05$) by the Tukey test.

RESULTS AND DISCUSSION

Growing response, food intake, and feed conversion rate (Table 2) were not significantly different among the sources and levels of zinc tested. Tests in chickens for fattening, which studied zinc sources, showed a similar effect of zinc in their growing (Salim et al., 2012; Zakaria et al., 2017). Meat color on the loin differed in L* and B* when supplemented with the organic source of zinc, being the lowest value when the organic source was used (Table 2). Meat color is an indicator of meat quality, and zinc has the ability to join myoglobin and increase oxygenation, which permits the maintenance of color (Zakaria et al., 2017). The pH, CRA, Protein content, fat, and humidity (data not shown) showed no differences, but collagen content was affected in loin; it was significantly lower when the organic source was used.

Table 2. Effect of different zinc sources and supplementation levels on growth performance, meat quality, and zinc content in White New Zealand rabbits.

Variable	Control	$ZnSO_4$		ZnMet		Zn source		Zn level		P-value		
		25	75	25	75	$ZnSO_4$	ZnMet	25	75	Source	Level	SxL
BW (kg)	2.03	2.05	2.01	2.01	2.13	2.03	2.07	2.03	2.07	0.355	0.445	0.094
Con (kg)	3.32	3.26	3.34	3.42	3.45	3.30	3.43	3.34	3.40	0.114	0.468	0.734
FCR (kg)	3.78	3.53	3.91	3.87	3.68	3.72	3.77	3.71	3.79	0.602	0.359	**0.005**
GS1 (g)	32.82	34.22	31.95	31.93	38.66	33.0	35.29	33.07	35.31	0.346	0.400	0.091
GS2 (g)	37.4	37.07	35.94	35.60	40.13	36.50	37.8	36.33	38.0	0.391	0.334	0.110
GS3 (g)	36.12	36.97	35.18	37.65	37.23	36.08	37.44	37.3	36.21	0.887	0.550	0.711
GS4 (g)	34.23	38.39	34.27	34.74	32.17	36.3	33.4	36.56	33.22	0.137	0.051	0.649
Leg												
L*	48.75	48.04	48.38	46.64	45.97	48.21	46.31	47.34	47.17	0.486	0.895	0.692
A*	18.09	18.32	17.24	17.48	17.53	17.81	17.51	17.9	17.37	0.653	0.410	0.363
B*	5.30	5.37	5.15	5.15	4.86	5.26	5.0	5.26	5.0	0.841	0.443	0.924
Col	1.17	1.22	1.22	1.15	1.15	1.22	1.15	1.19	1.18	0.121	0.897	0.990
Loin												
L*	47.67[a]	47.17	46.56	43.30	44.34	46.89[a]	43.82[b]	45.23	45.42	**0.024**	0.847	0.448
A*	12.16	11.48	12.09	11.99	11.52	11.78	11.76	11.73	11.80	0.837	0.895	0.348
B*	4.17[a]	3.83	4.53	3.94	3.49	4.16[a]	3.71[b]	3.88	4.01	**0.019**	0.563	**0.011**
Col	1.17	1.22	1.20	1.08	1.09	1.21[a]	1.09	1.15	1.14	**0.032**	0.943	0.786
Zinc content (mg. kg^{-1})												
Serum	2.86 [a]	2.55	2.16	2.53	2.27	2.35	2.4	2.54 [b]	2.21 [b*]	0.776	**0.030**	0.660
Liver	38.21	40.58	33.59	31.32	33.92	37.08	32.62	35.95	33.75	0.097	0.410	0.070
Loin	9.20 [b]	14.07	9.81	11.53	10.03	11.94	10.78	12.8 [a]	9.92 [ab]	0.345	**0.020**	0.260
Leg	10.79	10.15	12.69	11.79	10.48	11.42	11.13	10.97	11.55	0.767	0.570	0.070

BD= Body weight, Con= feed intake, FCR= feed conversion ratio, GS1= weekly gain 1, GS2= weekly gain 2, GS3= weekly gain 3, GS4, weekly gain 4, L*= Lightness, A*= redness, B*= yellowness, Col= Collagen, CRA= water holding capacity. Different letter indicate difference significant ($P<0.05$) (n=10) * Recovery of Zn was 87±4 % (n=3).

The highest content of zinc in serum was presented by control treatment (Table 2), which have no zinc supplementation, only with the mentioned ingredients in the supplied diet. This could be related to the utilization of zinc through feces softness. Contrary to what we have assumed, the highest levels of inclusion were those with the lowest content of circulating zinc in serum ($p=0.03$).

This is due to zinc is circulating and small amount of storage for the element is accomplished. Meanwhile, in liver, it has presented the highest content of zinc, this shoes that such organ is responsible for the distribution of minerals to whole organism. There was no greater retention of zinc when it was supplemented with different sources and levels of zinc. Therefore we assume that there is low amounts of availability of the element in the diet, the organism through physiological processes make an efficient use and reuse of the element, and could occur by ingesting soft feces from coprophagy, they are composed of protein, amino acids, B-complex vitamins and minerals (Blas and Wiseman 2010), although the proportion of minerals they reuse is still unknown. In loin, there were differences in the level of zinc inclusion ($p= 0.02$); the level 25 ppm had the highest zinc content in meat, while the inclusion of 75 ppm was greater than the control. In leg, there were no significant differences.

A greater deposition of zinc in rabbit meat contributes to generate a functional product which meets the nutritional requirements of zinc in humans, since meat is the main source of zinc for the human diet (Salim et al. 2012). More studies with different levels of zinc are needed to find out the best response in zinc deposition in rabbit meat.

CONCLUSION

The study has shown that zinc supplementation growth; meat-color was affected by the organic source. A smaller amount of collagen was found using the organic source. The level of 25 mg Kg^{-1} of zinc improves deposition of this element in loin meat in rabbits for fattening. Economically, the loin is the most important portion for human consumption.

REFERENCES

Alikwe, P. C. N., T. I. Ojiezeh, and S. A Olagboye. 2011. "Effects of Zinc Supplement on Rabbits Performance and Growth Rate." *Journal of Agriculture and Social Research 11 (2): 46–50.*

Blas, Carlos De, and Julian Wiseman. 2010. Minerals, Vitamins and Additives. *In: De Blas C., Wiseman J. (Ed). The Nutrition of the Rabbit, 2nd Edition,CABI Publishing, Wallingford, UK, 119-150. Doi:10.1079/9781845936693.0119.*

Chrastinová, Ľ., K. Čobanová, M. Chrenková, M. Poláčiková, Z. Formelová, A. Lauková, L. Ondruška, et al. 2016. "Effect of Dietary Zinc Supplementation on Nutrients Digestibility and Fermentation Characteristics of Caecal Content in Physiological Experiment with Young Rabbits." *National Agricultural and Food Centre 49 (1): 23–31.*

Cui, H., T. Zhang, H Nie, Z. Wang, X. Zhang, B Shi, X. Xing, F Yang, and X. Gao. 2017. "Effects of Different Sources and Levels of Zinc on Growth Performance, Nutrient Digestibility, and Fur Quality of Growing-Furring Male Mink (Mustela Vison)." *Biological Trace Element Research. https://doi.org/10.1007/s12011-017-1081-4.*

El-hack, M E Abd, M. Wahdan, S A Amer, M Arif, K M M Wahdan, and M. S. El-Kholy. 2017. "Effect of Dietary Supplementation of Organic Zinc on Laying Performance, Egg Quality and Some Biochemical Parameters of Laying Hens." *J Anim Physiol Anim Nutr, 1–8. https://doi.org/10.1111/jpn.12793.*

Kambe, T., T. Tsuji, A. Hashimoto, and N. Itsumura. 2015. "The Physiological, Biochemical, and Molecular Roles of Zinc Transporters in Zinc Homeostasis and Metabolism." *Physiological Reviews 95: 749–84.*

Meshreky, S. Z., S. M. Allam, M.A.F. El-Manilawi, and H F Amin. 2015. "Effect of Dietary Supplemental Zinc Source and Level on Growth Performance, Digestibility Coefficients and Immune Response of New Zealand White Rabbits." *Egyptian J. Nutrition and Feeds 18 (2): 383–90.*

Saleh, Ahmed A., Mohamed M. Ragab, Enas A. M. Ahmed, Alaeldein M. Abudabos, and Tarek A. Ebeid. 2018. "Effect of Dietary Zinc-Methionine Supplementation on Growth Performance, Nutrient Utilization and Antioxidative Properties in Broiler Chickens under High Ambient Temperature." *Journal of Applied Animal Research 46 (1): 820–27.*

Salim, H M, H R Lee, C Jo, S K Lee, and Bong Duk Lee. 2012. "Effect of Sex and Dietary Organic Zinc on Growth Performance, Carcass Traits, Tissue Mineral Content, and Blood Parameters of Broiler Chickens." *Biol Trace Elem Res, no. 147: 120–29. https://doi.org/10.1007/s12011-011-9282-8.*

Xu, X., L. Liu, S. F Long, X. S. Piao, T. L. Ward, and F. Ji. 2017. "Effects of Chromium Methionine Supplementation with Different Sources of Zinc on Growth Performance, Carcass Traits, Meat Quality, Serum Metabolites, Endocrine Parameters, and the Antioxidant Status in Growing-Finishing Pigs." *Biol Trace Elem Res 179: 70–78.*

Yan, J. Y., G. W. Zhang, C. Zhang, L. Tang, and S. Y. Kuang. 2017. "Effect of Dietary Organic Zinc Sources on Growth Performance, Incidence of Diarrhea, Serum and Tissue Zinc Concentrations, and Intestinal Morphology in Growing Rabbits." *World Rabbit Science 25 (1): 43–49. https://doi.org/10.4995/wrs.2017.5770.*