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Organic zinc supplementation and pigs productive performance in warm environment

Suplementación con zinc orgánico y rendimiento productivo de cerdos en ambiente caluroso

Romo-Valdez Juan[1], Romo-Valdez Ana[1], Montero-Pardo Arnulfo[1], Urías-Castro Christian[1], Güémez-Gaxiola Héctor[1], Romo-Rubio Javier[1*]

[1]Faculty of Veterinary Medicine and Zootechnics of the Autonomous University of Sinaloa; Culiacán, Sinaloa, Mexico; *Responsible and correspondence author: Romo-Rubio Javier. Faculty of Veterinary Medicine and Zootechnics of the Autonomous University of Sinaloa; Boulevard San Ángel s/n, Colonia San Benito, Culiacán de Rosales, Sinaloa, Mexico; CP 80246. romo_14@hotmail.com, e.ana.romo@uas.edu.mx, arnulfomp@hotmail.com, el_magnum1@hotmail.com, hectorguem@gmail.com, romo60@uas.edu.mx

Abstract

In order to evaluate the influence of organic zinc supplementation on the performance of developing pigs in a warm environment (t 30.4 °C, RH of 73% and THI 82), 96 pigs of 84 d of age were used (33.8±0.96 kg of live weight) in a randomized complete block design. The treatments were: 1) Control (n=24), corn/soybean-based developing pig diet; 2) Control plus 120 ppm Zn/kg of DM; 3) Control plus 240 ppm Zn/kg of DM, and 4) Control plus 360 ppm organic Zn/kg of DM. Zinc was provided as zinc methionine (ZnMet). The pigs in groups of eight (4 males and 4 females) were placed in 12 pens (3 per treatment). The pen was the experimental unit. The pigs were weighed on days 1 and 42; fed intake, air temperature, and RH were recorded daily. The results were analyzed by ANOVA (p<0.05) and the influence of the Zn level on the productive response was explored by orthogonal polynomials. Quadratic responses were observed at the Zn supplementation level in the final weight (P=0.05), daily weight gain (P=0.03) and daily feed intake (P=0.05). The feed conversion tended (P=0.08) to improve linearly as the Zn level increased, with mean values of 2.97, 2.83, 2.90 and 2.70 kg of feed/kg of gain, for Control, 120 ZnM, 240 ZnM, and 360 ZnM, respectively. The results indicate that the diets intake supplemented with Zn improves the feed conversion of pigs during the development stage, under warm environment condition.

Keywords: zinc methionine, pig, productive performance.

Resumen

Con el objetivo de evaluar la influencia de la suplementación con zinc orgánico en el rendimiento de los cerdos en desarrollo en ambiente caluroso (t 30.4°C; HR de 73% y THI 82), se usaron 96 cerdos de 84 d de edad (33.8 ± DE 0.96 kg de p.v.) en un diseño de bloques completos al azar. Los tratamientos fueron: 1) Testigo (n = 24), dieta de desarrollo basada en maíz/soya; 2) Testigo más 120 ppm de Zn/kg de MS; 3) Testigo más 240 ppm de Zn/kg de MS, y 4) Testigo más 360 ppm de Zn orgánico/kg de MS. El zinc se proporcionó como metionina de zinc (ZnMet). Los cerdos, en grupos de ocho (4 machos y 4 hembras), fueron colocados en 12 corrales (3 por tratamiento). El corral fue la unidad experimental. Los cerdos se pesaron los días 1 y 42; el consumo de alimento, la temperatura del aire y la humedad relativa (HR) se registraron diariamente. Los resultados se analizaron mediante ANDEVA (p <0.05) y la influencia del nivel de Zn en la respuesta productiva se exploró mediante polinomios ortogonales. Se observaron respuestas cuadráticas al nivel de suplementación con Zn en el peso final (P = 0.05), ganancia diaria de peso (P = 0.03) y consumo diario de alimento (P = 0.05). La conversión alimenticia tendió (P = 0.08) a mejorar

linealmente a medida que se incrementó el nivel de Zn, con valores medios de 2.97, 2.83, 2.90 y 2.70 kg de alimento/kg de ganancia, para el testigo, 120 ZnM, 240 ZnM y 360 ZnM, respectivamente. Los resultados indican que el consumo de dietas suplementadas con Zn mejora la conversión alimenticia de los cerdos durante la etapa de desarrollo, bajo condiciones de ambiente cálido.
Palabras clave: metionina de zinc, cerdo, rendimiento productivo.

INTRODUCTION

Heat stress causes alterations in the metabolic system (Baumgard y Rhoads, 2013). These include the decrease in the release of thyroid and growth hormones, which decreases the basal metabolic rate (Aggarwal y Upadhyay, 2013), which affects the expression of genes and proteins involved in the metabolism of energy and nutrients (Sanz-Fernandez *et al*., 2015). Zinc is a trace mineral with proven importance for the function of more than 300 enzymes (Chasapis *et al*., 2012). The metabolic action of Zn includes energy metabolism, protein synthesis, nucleic acid metabolism, epithelial tissue integrity, repair and cell division, transport and utilization of vitamin A and vitamin E absorption (Borah *et al*., 2014).

It has been shown that diets supplemented with Zn improves and prevents the reduction of intestinal integrity during heat stress (Sanz-Fernandez *et al*., 2014), decreases the intestinal permeability of piglets during weaning (Zhang y Guo, 2009), promotes the restoration of the intestinal epithelium (Song *et al*., 2011) and improves the metabolism of proteins in pigs (Pearce *et al*., 2015). Because Zn requirements increase during heat stress (Lagana *et al*., 2007), it has been suggested that Zn supplementation could be used to attenuate the decrease in serum Zn during periods of high ambient temperatures (Li *et al*., 2015).

Pig diets are usually supplemented with inorganic Zn ($ZnSO_4$ or ZnO) to ensure the required demand. $ZnSO_4$ is the inorganic source with the highest bioavailability (NRC, 2012); however, under normal physiological conditions and with adequate intake, only 5 to 15% of the diet is apparently absorbed (McDowell, 2003).

In recent years, the use of organic sources of Zn has been explored, due to its greater bioavailability (Sahin *et al*., 2005).
The objective of the present study was to evaluate the influence of organic zinc supplementation, from zinc methionine, on the performance of developing pigs in warm weather conditions.

MATERIAL AND METHODS

The study was carried out from August to October 2016 in the Experimental Unit of Fattening Pigs of the Faculty of Veterinary Medicine and Zootechnics of the Autonomous University of Sinaloa, located in the pig farm "La Huerta", located in the municipality of

Culiacán, Sinaloa, Mexico (24° 49' 38'' N and 107° 22' 47'' W, and 60 meters above sea level); with an average annual ambient temperature of 25 °C and 790 mm of rain (INEGI, 2013).

Experimental design. Ninety-six 84-day-old pigs (48 males and 48 females; 33.8±SD 0.96 kg l.w) were used in a randomized complete block experimental design (DBCA). Pigs were weighed individually; they were grouped into three blocks by initial weight and sex, and in groups of eight (4 males and 4 females); the pigs were placed in 4 pens per block.

The pen was the experimental unit. The treatments were: 1) diet based on meal of corn and soybean (see table 1), with nutritional contribution according to the production stage (control); 2) Control plus 120 ppm of organic Zn/kg of DM (120 ZnM); 3) Control plus 240 ppm of organic Zn/kg of DM (240 ZnM), and 4) Control plus 360 ppm of organic Zn/kg (360 ZnM).

Organic zinc was provided as zinc methionine (ZnMet) of the Zinpro 120 premix (Zinpro® 120, contains 12% of Zn and 27.3% of methionine; Zinc methionine in US Patent Nu. 4,764,633 and 5,430,164; Mexico release office: B00.02.08.02.02.0398/11)

Table 1. Composition and nutritional information of the diet used in the development stage

Ingredients (kg)	Development
Corn	749
Soybean Paste	217
Oil	9
Mineral premix	25
Nutritional contribution	
E.M.(Mcal Kg^{-1})	3.351
Protein (%)	16.702
Lysine (%)	1.052
Fiber (%)	2.524
Phosphorus (%)	0.520
Calcium (%)	0.570
*Zinc (ppm)	120.28

* Zn content of the control diet, provided by the mineral premix such as ZnO.

Animal handling Pigs were weighed, identified and grouped into groups of eight in 7x1.5 m (10.5 m2) pens, which includes 1.5 m^2 of pond; with concrete floor and completely roofed, equipped with plastic feeder type hopper with integrated metal pacifier. Pigs had permanent access to water and food freely available. The animals were weighed at the beginning (day 0) and 42 days after starting the test, to determine the daily weight gain (DWG) in the study period. The food offered to the pigs of each pen was recorded and at the end of the period the daily feed consumption (DFC) was determined. On the basis of DFC and DWG, the feed conversion (FC=DFC/DWG) was calculated.

Measurement of temperature and relative humidity. The temperature (t °C) and relative humidity (RH, %) data were taken with a thermo hygrometer, located inside the experimental unit, and recorded daily during the experimental period (Table 2). The temperature and humidity index (THI) was calculated using the formula THI= [0.8 x room temperature] + [(% RH/100) x (room temperature-14.4)] + 46.4 (Mader *et al*., 2006).

Table 2. Temperature and humidity index (THI) to which the pigs were exposed during the experimental period

Week	Aver RH .	Aver Temp. .(°C)	Min Temp (°C)	Max Tem (°C)	Aver THI[1]	Min THI.	Max THI.
1	73.4	30.0	25.0	35.0	81.85	74.18	89.60
2	71.0	31.1	24.6	37.6	83.13	73.32	92.95
3	72.8	30.2	24.9	35.5	82.06	77.60	90.16
4	76.1	30.4	24.0	34.8	82.89	72.90	89.76
5	73.7	30.0	24.4	35.6	81.89	73.29	86.50
6	71.4	31.0	24.8	37.2	83.05	73.66	92.40
Average	73.06	30.45	24.61	35.95	82.47	74.15	90.22

[1]Temperature and humidity index (THI) = 0.8 × Room Temperature + [(% relative humidity ÷ 100) × (room temperature − 14.4)] + 46.4. THI ranges (normal THI <74; alert 75 a 79; danger 79 a 84; and emergency >84). 1

Statistical analysis. The results were analyzed by ANDEVA (Steel y Torrie, 1985) for a DBCA. The influence of the Zn level in the productive response was explored by orthogonal polynomials. An alpha value of 0.05 was established to accept statistical difference and each pen was considered as the experimental unit. All calculations were performed using version 8 of the Statistix® Statistical, statistical package.

RESULTS

During the experimental period, the average temperature was 30.4 °C; relative humidity 73%, and THI of 82. The results of the influence of the addition of Zn from ZnMet on the productive response of developing pigs are shown in Table 3. Pigs fed diets supplemented with Zn (ZnMet) had a better feed conversion (P=0.05). Quadratic responses to the level of organic Zn supplementation were observed in the final weight (P=0.05), weight gain (P=0.03) and food consumption (P=0.05). The feed conversion tended (P=0.08) to improve linearly as the level of organic Zn increased.

Table 3. Influence of the additional level of Zn from zinc methionine on the productivity of developing pigs

Variable	Additional level of Zn, mg/kg				EEM[1]	Value of P	Polynomials		
	0	120	240	360			Linear	Quadratic	Cubic
Pigs	24	24	24	24					
Pens, n	3	3	3	3					
Days of trial	42	42	42	42					
Initial weight, kg	33.700	34.033	33.700	33.700	0.144	0.35	0.62	0.29	0.17
Final weight, kg	59.233[ab]	56.733[b]	57.933[b]	61.767[a]	1.291	0.09	0.18	0.05	0.86
DWG[2], kg	0.608[ab]	0.541[b]	0.577[ab]	0.669[a]	0.029	0.05	0.13	0.03	0.73
DFC[3], kg	1.814[a]	1.536[b]	1.673[ab]	1.802[ab]	0.087	0.06	0.81	0.05	0.31
FC[4]	2.967[a]	2.833[ab]	2.900[ab]	2.700[b]	0.080	0.05	0.08	0.69	0.23

[1]Standard error of the mean; [2]Daily weight gain; [3]Daily consumption of food; [4]Food conversion.

DISCUSSION

High ambient temperatures can negatively affect animals (Chauhan *et al*., 2014); these, by themselves, can be fatal, but in many areas, high relative humidity also contributes significantly to raising the sensation of heat (Parsons, 1995). The hot and humid conditions during the summer, implies a certain risk that the pigs will be affected by heat stress (HS).

In the present study, experimental animals were exposed to an average temperature and relative humidity of 30.4 °C and 73% RH, respectively, for 42 days; which according to Mader *et al.* (2006), pigs were at risk of HS in a range of physiological emergency danger, with a THI between 74.15 and 90.22 and a daily average of 82.47 (see table 2).

The high ambient temperature decreases the plasma concentrations of Ca, K, Na and Zn in animals undergoing HS (Pearce *et al*., 2013); because the Zn requirements increase during the HS (Lagana *et al*., 2007). It has been suggested that Zn supplementation could be used to attenuate the serum decrease of Zn during periods of high ambient temperatures (Li *et al*., 2015).

In Japanese quails under HS conditions, $ZnSO_4$ supplementation improved food consumption, egg production, egg quality, feeding efficiency and nutrient digestibility (Sahin y Kucuk, 2003).

In broilers, supplementation with $ZnSO_4$ improved weight gain and feed conversion, while reducing oxidative stress (Kucuk *et al*., 2003). Also, improvement in the function of the intestinal barrier has been observed, when pigs are supplemented with Zn during HS (Sanz-Fernandez *et al*., 2014).

In the present study, pigs fed a diet supplemented with Zn (ZnMet), at levels of 120, 240 and 360 mg/kg DM, had a better feed conversion; showing a quadratic response in food consumption, daily weight gain and final weight; while food conversion had a linear trend. These results are similar to those observed by Li *et al*. (2015) in pigs fed a diet supplemented with 1,500 mg of Zn ($ZnSO_4$) under HS conditions (40 °C for 5 h daily in a period of 8 consecutive days). Other studies have also suggested that the consumption of diets added with inorganic Zn, at pharmacological levels, improves the productive response of pigs (Carlson *et al*., 1999; Mavromichalis *et al*., 2001).

The diet used in the present study contained 120.28 mg Zn/kg DM, from inorganic Zn, contributed by the mineral premix. The NRC (2012) recommends a contribution of 60 mg of Zn/kg of feed for pigs of 20-50 kg of live weight, and 50 mg of Zn/kg of feed for pigs of 50-110 kg of live weight. The supplementary source has generally been inorganic Zn from $ZnSO_4$ or ZnO, the inorganic source of $ZnSO_4$ being the most bioavailable (NRC, 2012). However, under normal physiological conditions and with adequate intake, only 5 to 15% of the diet Zn is apparently absorbed (McDowell, 2003); which suggests that only between 6.01 and 18.04 mg of the Zn contributed per kg of feed is absorbed by the pig under normal conditions. Li *et al*. (2015) observed that exposure to caloric stress decreases serum zinc concentration in miniature pigs; it has also been suggested that oxidative stress may contribute to micronutrient deficiency by increasing the demand for antioxidants, including Zn, selenium and vitamins A, C and E (Sappey *et al*., 1994); what it could explain, the improvement observed in feed conversion in pigs that consumed feed added with organic Zn.

The results of the present study indicate that supplementation with 360 mg of Zn (ZnMet)/kg of DM improves (P=0.5) the nutritional conversion of developing pigs into heat stress.

CONCLUSION

The consumption of diets supplemented with 360 mg of Zn/kg of DM, from zinc methionine, improves the nutritional conversion of the pigs in development, raised in environmental conditions with high heat stress.

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