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PRODUCTIVE PERFORMANCE IN PIGS SUPPLEMENTED WITH INCREASING LEVELS OF ORGANIC SELENIUM

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ABSTRACT

The objective of this study was to determine the productive performance of pigs, during the starter (from 11 to 25 kg of live weight) and grower (from 25 to 50 kg of live weight) stages, supplemented with increasing levels of dietary organic selenium under tropical conditions. Pigs (n=71) were distributed in randomized block design with four treatments (0, 0.3, 0.6, and 0.9 mg kg^{-1} of feed). Organic selenium was included in the diet as selenomethionine (SeMet) from the BIOWAYS® product with a concentration of 2,000 ppm. The study was conducted over a 70-day period. The variables evaluated were voluntary feed intake, daily weight gain, and feed conversion. The daily weight gain varied between treatments in the starter stage, with average values of 0.431, 0.510, 0.466, and 0.554 g day^{-1} (P<0.05), but similar values of 0.890, 0.809, 0.908 and 0.884 kg day^{-1} were obtained in the grower stage for treatments with 0, 0.3, 0.6 and 0.9 mg kg^{-1} of feed, respectively. Feed conversion in the starter and grower stages improved when pigs were supplemented with selenium (P<0.05). Overall, supplementation with organic selenium improves daily weight gain and feed conversion in pigs during the starter and grower stages.

Keywords: animal welfare, weight gain, efficiency, tropics.

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INTRODUCTION

In recent years, the rapid increase in global population has increased the demand for protein and energy of animal origin, with livestock activities contributing 17% of the calories and 33% of the protein consumed in the world (UN, 2019). However, the capacity of animal production systems to meet the demand for products will be seriously affected due to the increase in the prices of agricultural inputs (fertilizers, grains, and oilseeds), which will cause a reduction in the production capacity of the primary sector. The lower production of feeds of animal origin will accentuate feed insecurity mainly in less developed countries. In fact, current projections indicate that by 2030, feed insecurity will affect more than 30% of the population (FAO, 2021). Currently, 811 million people suffer from hunger in the world, with alarming increases in 2021 and 2022 because of the SARS-CoV-2 pandemic and its effect on the agricultural and livestock sector (FAO, 2021).

Pig farming is an activity of socioeconomic importance, being pork the most consumed meat in the world, with an annual production of 114.5 million tons. However, this activity is mostly carried out in temperate climates with temperatures between 18 and 25°C (Bing et al., 2021). When temperatures exceed the optimal range, as happens in tropical regions where this activity is increasing, production is affected by heat stress (Baumgard et al., 2013). Therefore, strategies must be implemented to reduce stress and increase productivity in swine production systems in warm regions. In this sense, various studies indicate that supplementation with organic selenium improves production parameters at different growth stages (Mahan et al., 2014; Ma et al., 2017).

It has been described that the inclusion of organic selenium in the diet of pigs has favorable effects on heat stress by improving the immune system and intestinal health (Galaz-Galaz et al., 2018). Zhang (2020) reported that including organic selenium at a dose of 1 mg kg^{-1} DM, in the diet of pregnant sows, increased milk production, while the weight of the piglets at weaning was higher. In fattening pigs, improvements in daily weight gain and feed efficiency have been reported. In addition, a study conducted by Davila (2020) reported an improvement in the immune system in pigs subjected to heat stress, with inclusion levels of 0.2 and 0.3% of DM in the diet during the grower and finishing phases. We hypothesize that supplementation of organic selenium in the diet of pigs reduces heat and humidity stress, which may increase voluntary feed intake and daily weight gain. Therefore, the objective of this study was to determine the productive response in pigs at the starter and grower stages supplemented with organic selenium under tropical conditions.

MATERIALS AND METHODS

Study site

The study was carried out in the POSTA experimental area from the Technological Institute of Conkal, Yucatán (Mexico). The site is located at km 2 from the Conkal- Chablekal highway (latitude 21° 02′ and 21° 08′ N and longitude 89° 29′ and 89° 35′ W), at an average altitude of 8 meters above sea level. The region is dominated by a warm subhumid climate with regular rains in summer (May–July), with an average annual temperature of 26.6°C, an average annual rainfall of 469 mm, and an average annual relative humidity of 77.5% (INEGI, 2013). The study was carried out from March to December 2022, considering both seasons (rainy and dry). Temperature and relative humidity were recorded daily inside the pen where the metabolic cages were placed throughout the experimental phase. The average temperature was 32.16 °C (23.91 °C to 34.18 °C) and the relative humidity was 79.16% (54 to 99%).

Animals and treatments

Pigs (n=71) from the PIC® genetic line were used for fattening, with an average live weight (LW) of 11 ±1 kg. The experiment was conducted over a 70-day period using a randomized block design. The animals were weighed individually at the beginning of the experiment and distributed into four treatments and four blocks per treatment. The experimental treatments were: 0.0 mg kg^{-1} (n=17), 0.3 mg kg^{-1} (n=18), 0.6 mg kg^{-1} (n=18), and 0.9 mg kg^{-1} (n=18) of feed. Organic selenium was included in the diet as selenomethionine (SeMet) from the BIOWAYS® product with a concentration of 2,000 ppm, with 44% protein (SADER: A-1051-002). Prior to the start of the study, the animals were dewormed with 1% SANFER® Ivermectin (1 mL per 33 kg of live weight), vitaminized with strong Vigantol® ADE (2 mL per pig), and vaccinated against Pneumonic Pasteurellosis® (2.5 mL per pig) (Table 1).

Animal management

The pigs were individually weighed and distributed in pens provided with feeders and automatic water troughs. The pigs had access to water and feed *ad libitum.* The animals were weighed individually at the beginning of the experiment and every eight days thereafter to determine the daily weight gain (DWG) per

Table 1. Nutrient composition of the diet in the different stages of fattening.

	Fattening stages	
Ingredients (kg)	**Starter**	**Grower**
Corn grain	366.91	587.11
Soybean meal	398.33	291.65
Vegetable oil	75.50	6.18
Molasses	50.00	50.00
Lysine	2.76	2.13
Methionine	5.10	3.89
Common salt	25.00	25.00
Carbonate	44.64	3.31
Phosphate	6.75	5.73
Vitamins and minerals	25.00	25.00
	Chemical composition	
Protein (%)	18.87	15.68
Lysine (%)	1.41	1.12
Methionine (%)	0.79	0.65
Calcium (%)	1.7	0.66
Match (%)	0.6	0.56
ME (Mcal kg^{-1})	3.35	3.30

*Content of SiO_2, $AI2O_3$, K_2O, Na_2O, CaO, MgO, Fe_2O3 of the diet as a mycotoxin sequestrant in the diet, provided by BIOTETOX®. ME: Metabolisable energy.

feeding stage. To determine feed consumption, the feed offered and rejected was recorded. Feed conversion was calculated by dividing consumption per period by weight gain (WW) (kg kg^{-1}).

Diet formulation

Nutritional requirements for the starter and grower stages were obtained from the NRC (2012). The inclusion of the ingredients was determined using the linear programming procedure at minimum cost with the LINGO® software.

Chemical analysis

The dry matter content was determined using a forced air oven at 55°C for 48 h (constant weight, method #7.007). Nitrogen (CP= N × 6.25) was determined using a LECO CN-2000 series 3749 instruments (LECO Caopr., St. Joseph, MI) (#2.057) AOAC (1980). The organic matter content was determined by combustion in the muffle at 600°C for 6 hours.

Analysis of data

The data on voluntary feed intake, daily weight gain, and feed conversion were analyzed using the SAS PROC ANOVA procedure (Cody and Smith 1991; SAS 2009) for a randomized complete block design (SAS, 2009). The means of the treatments were compared using a Tukey test ($p \leq 0.05$; Cody and Smith 1991; SAS 2009).

RESULTS

Pigs fed with diets supplemented with organic selenium increased daily weight gain at the starter stage, and there were differences between the control treatment and 0.9 mg/kg, with an average daily weight gain of 0.431 vs. 0.554 g day^{-1}, respectively ($p \leq 0.05$) (Table 2). Feed conversion had the same trend, with a difference between the selenim inclusion of 0.3 mg kg^{-1} and 0.9 mg kg^{-1} ($P<0.05$). Voluntary feed consumption was different between the control treatments compared to 0.9 mg kg^{-1}.

At the grower stage, the daily weight gain was similar between treatments, with an average of 0.867 g day^{-1} ($P>0.05$). The best feed conversion occurred in the treatment with 0.6 mg kg^{-1} of selenium ($P<0.05$). The lowest feed intake was recorded with the supplementation of 0.6 and 0.9 mg kg^{-1} of dietary selenium ($P<0.05$) (Table 3).

DISCUSSION

Environmental temperatures above the thermoneutral zone (comfort zone) for pigs are common in tropical regions (Yu et al., 2020),

Table 2. Effect of the addition of organic selenium on productive performance in fattening pigs at the starter stage (11 to 25 kg of live weight).

	Treatments					
Variables	Control	0.3 mg kg^{-1}	0.6 mg kg^{-1}	0.9 mg kg^{-1}	SE	P-value
N	17	18	18	18		
IW (kg)	11.41	1151	11.52	11.22	0.222	0.7260
FW (kg)	23.85b	26.81ab	25.48ab	27.85a	0.743	0.0013
DWG (g day^{-1})	0.431b	0.510ab	0.466ab	0.554a	0.024	0.0006
FC (kg)	6.05a	4.82ab	4.82ab	3.96b	0.253	0.0001
FI (kg)	65.89b	60.93ab	59.18ab	57.79a	0.945	0.0001

IW: initial weight. FW: final weight. LW: live weight. DWG: daily weight gain. FC: feed conversion. FI: feed intake. SE: standard error. $^{a, b}$ Different letters within the same row indicate significant differences (P<0.05).

Table 3. Effect of the addition of organic selenium on productive performance in fattening pigs at the grower stage (25 to 50 kg of live weight).

	Treatments					
Variables	Control	0.3 mg kg^{-1}	0.6 mg kg^{-1}	0.9 mg kg^{-1}	SE	P-value
N	17	18	18	18		
IW (kg)	23.85b	26.81 ab	25.48 ab	27.85 a	0.743	0.0013
FW (kg)	50.53b	51.09b	52.73 ab	54.36 a	0.913	0.0116
DWG (g day^{-1})	0.890	0.809	0.908	0.884	0.029	0.0740
FC (kg)	3.73ab	3.85ab	3.30b	3.37b	0.154	0.0230
FI (kg)	86.69 a	83.61a	79.36b	79.06b	1.342	0.0001

IW: initial weight. FW: final weight. LW: live weight. DWG: daily weight gain. FC: feed conversion. FI: feed intake. SE: standard error. $^{a, b}$ Different letters within the same row indicate statistical differences (P<0.05).

reaching up to 40°C during dry seasons. These warm environmental conditions usually cause a reduction in the productive performance of growing pigs, which reduces the profitability of the production system (Mayorga et al., 2021). In this study, greater weight gains were observed with the selenium inclusion of 0.9 mg kg^{-1}, as well as improved feed conversion, and lower feed intake. Similar results were found by Zhang et al. (2020), who reported that including 0.3 mg kg^{-1} of dietary organic selenium results in greater weight gains in the fattening stage, which was partly attributed to an increase in animal welfare. Similarly, Falk (2018) carried out a study on pigs at the finishing stage, in which dietary organic selenium was included at 0.4 mg kg^{-1}, and reported a lower susceptibility to oxidative stress in the meat. On the other hand, Song et al. (2013) reported that adding 0.3 mg kg^{-1} of dietary organic selenium to fattening pigs results in a higher level of blood metabolites that promote greater immunity.

Mrazova et al. (2020) determined the effect of consuming pork supplemented with organic selenium on blood serum in humans with an addition of 0.3 mg kg^{-1} in the diet and reported an increase in selenium concentration and a decrease in total cholesterol in the blood serum in humans. The increase in daily weight gain and improvement in pork quality, when animals are supplemented with organic selenium, is explained by improved animal welfare, resulting in the prevention of cellular oxidative stress in the body. Consuming pork enriched with organic selenium could have positive effects on human health by reducing cardiovascular and cancer diseases. However, further research is required, including a full fatty acid profile analysis of pork, to clearly elucidate the effects on human health.

CONCLUSION

Overall, supplementation with 0.9 mg kg^{-1} of dietary organic selenium at the starter stage in pigs improved daily weight gains and feed conversion. At the grower stage, supplementation with organic selenium at a dose of 0.6 mg kg^{-1} improved feed conversion and reduced total feed intake without affecting daily weight gains. It can be concluded that the use of organic selenium during the early stages of growth improves the productive performance of pigs raised under tropical conditions.

Author contributions

The authors present in this manuscript actively participated in the development of this study: Fabian Valera-Lara, Michelle Estrada-Gijon. The following participated in the methodological design: Jose Sangines-Garcia. The following participated in the writing, revision and discussion of the manuscript, as well as the approval of the final version of the document: Fabian Valera-Lara, Jose Sangines-Garcia, Einar Vargas-Bello-Pérez, Alfonso Chay Canul, Ángel Trinidad Piñeiro-Vázquez and Adelfo Vite-Aranda.

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