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Evaluation of Fe, Cu, Mn and Zn in manure of weaned pigs receiving high levels of organic or inorganic supplementation.

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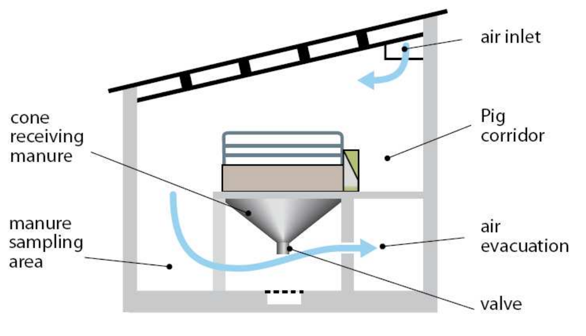
Introduction

Satisfying the requirements for optimal performance and minimizing the environmental impact of trace minerals is a concern for pig nutrition. In 2003, the risk of accumulation of trace elements in cultivated soils receiving the liquid manures of pigs justified a limitation of trace element contents in animal feeds. A 40 days experiment has been undertaken to evaluate the Fe, Cu, Mn and Zn excretion of piglets given the upper concentrations allowed by European legislation in compound feeds.

Materials and methods

40 male and female piglets were weaned at 28 ± 1 days and blocked on basis of sex and initial weight (mean = 8.0 kg). 20 weaners per treatment were housed in 2 (male and female) plastic and stainless steel pens designed for total collection of manure and located in a temperature controlled room (Figure 1). Pigs were given *ad libitum* access to feed and water during the 40 days experiment.

Figure 1 Experimental unit plan



Dietary treatments consisted of addition of 110 mg of Fe, 150 mg of Cu, 50 mg of Mn and 110 mg of Zn/kg of diet as inorganic ($FeSO_4$, $CuSO_4$, $MnSO_4$, ZnO) or organic (Bioplex) sources. A phase 1 diet with wheat, soybean meal, fat filled whey powder, minerals and amino acids as base components was fed for 14 days followed by a phase 2 diet including wheat, corn, peas, soybean meal, rapeseed meal, oil, minerals and amino acids for an additional 25 days. The diets were prepared in meal form, did not contain microbial phytase and met or exceeded the nutrient recommendations (ITP, 2002) for piglets (Table 1).
Individual weights were determined at the beginning of the experiment (d 0) and at the end of phases 1 (day 15) and 2 (day 40), and feed and water consumptions were calculated per pen. The collect and sampling of the manures were carried out at the end of the phase 1 period and at the end of the experiment. Manure samples were homogenized and concentrations in Dry Matter, Nitrogen, Phosphorus, Fe, Cu, Mn and Zn were obtained.

Results and discussion

The analyzed concentrations of Fe, Cu, Mn and Zn in the control and experimental diets showed a good concordance. The results were respectively of 228, 161, 72, 120 and 239, 145, 76 and 145 mg /kg for phase1 diets, and 279, 156, 70, 126 and 274, 143, 75, 150 mg/kg for phase 2 diets. A lower grade of the commercial zinc oxide used could explain that control diets had slightly lower contents in zinc than expected. There were no differences in average daily feed intake, daily gain and manure production by animals.

Figure 2 Effects of dietary Fe, Cu, Mn and Zn supplementation on piglet excretion.

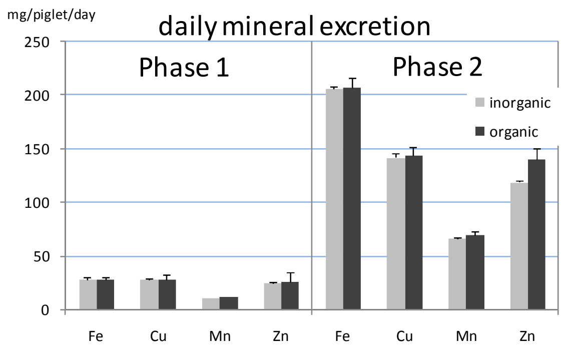


Table 1. Calculated nutrient content of the diets (as fed basis. mg, g, or U per kg).

	DM	CP	CF	Starch	Fat	NE	digLys	Ash	Ca	P	digP	PhyticP	Phy activity	Fe	Cu	Mn	Zn
Phase 1	908	206	31	309	93	11.4	14.3	52	6.4	5.5	3.0	2.1	255	251	155	76	139
Phase 2	889	190	42	411	45	10.0	12.0	56	9.7	7.2	3.5	2.6	205	274	154	77	142

Table 2 Effects of dietary Fe, Cu, Mn and Zn supplementation on piglet mineral intake and excretion.

	Inorganic			Organic		
g/pig	intake	excretion	%	intake	excretion	%
Phase 1 (day 0 to 15)						
Fe	1.13 ± 0.01	0.42 ± 0.02	37%	1.18 ± 0.10	0.42 ± 0.02	36%
Cu	0.80 ± 0.01	0.41 ± 0.02	51%	0.72 ± 0.06	0.42 ± 0.04	58%
Mn	0.35 ± 0.00	0.16 ± 0.01	44%	0.37 ± 0.03	0.17 ± 0.00	46%
Zn	0.60 ± 0.00	0.36 ± 0.03	60%	0.71 ± 0.06	0.39 ± 0.09	54%
Phase 2 (day 16 to40)						
Fe	7.29 ± 0.07	5.15 ± 0.07	71%	7.06 ± 0.46	5.18 ± 0.21	73%
Cu	4.10 ± 0.04	3.54 ± 0.09	86%	3.69 ± 0.23	3.58 ± 0.21	97%
Mn	1.85 ± 0.02	1.64 ± 0.05	89%	1.94 ± 0.12	1.74 ± 0.10	89%
Zn	3.30 ± 0.03	2.96 ± 0.03	90%	3.86 ± 0.24	3.51 ± 0.26	91%
Overall (day 0 to 40)						
Fe	8.43 ± 0.08	5.57 ± 0.09	66%	8.24 ± 0.56	5.61 ± 0.23	68%
Cu	4.90 ± 0.04	3.95 ± 0.07	81%	4.41 ± 0.29	4.00 ± 0.25	91%
Mn	2.20 ± 0.02	1.79 ± 0.05	81%	2.31 ± 0.15	1.91 ± 0.09	82%
Zn	3.90 ± 0.04	3.32 ± 0.06	85%	4.58 ± 0.30	3.90 ± 0.35	85%

[a] Results are given as means ± SD for 2 pens per group.

The analyzed values of Fe, Cu, Mn and Zn in phase 1 and 2 diets and manures were used to determine apparent balances (Table 2). Excretion of Fe, Cu and Mn did not differ for inorganic (respectively 5.6, 4.0 and 1.8 g/pig) and organic (respectively 5.6, 4.0 and 1.9 g/pig) sources, whereas the zinc excretion was slightly lower for pigs receiving the inorganic elements (3.3 g/pig) than for those given the organic form (3.9 g/pig), which was probably caused by the lower concentration in control diets. There was a dramatic increase of Fe, Cu, Mn and Zn excretion rates during phase 2 (Figure 2).

The piglets receiving the phase 2 diets excreted comparable quantities to those reported in previous studies for diets containing similar concentrations of inorganic or organic Zn (Buff et al., 2005; Gaudré et al., 2006). On a percentage basis, Zn excretion rates were identical to those calculated in previous research (Buff et al., 2005) whereas piglets fed diets containing between 28 and 58 mg/kg have lower coefficients of excretion (Revy et al., 2002). In phase 1, Zn contents of our diets exceed the recommended supply of 100-110 mg/kg diet up to 16 kg with zinc as sulphate (Revy et al., 2006). As ZnO is a poor available source of Zn, the safety margin should be enhanced and needs could be estimated about 120-130 mg/kg (Revy et al., 2006). On the other hand, the medium level of natural phytase (250/200 FTU/kg) in the diets could have increase the digestibility of dietary Zn. For the phase 2 period requirements could be lowered to 100 mg (Gaudré et al., 2006).

For other elements, the apparent balance data is related to intake and excretion values reported by Veum et al. (2004) for Cu in phase 2 and by Rincker et al. (2005) for Fe in phase 1. In a second trial, Rincker et al. (2005) observe lower intake and excretion values because of a poorer performance level.

Accumulation of Cu and Zn in the soil is a problem for some European regions, but recommended requirements of piglets and pigs vary widely among different countries (Jongbloed, 2007). Modern genotypes, interaction of ingredients, microbial phytase are factors modifying the evaluation of the needs. Jondreville et al. (2003) and Jongbloed (2007) discussed that a further reduction of Zn and Cu excretion may be obtained in the future with the help of better feeding strategies and high availability of Cu and Zn sources.

Conclusion

It can be concluded that when high safety margins above the physiological requirements are applied, the excretion values per animal remain important. Thus, the environmental effects of trace elements could be reduced by a lower supplementation rate of these metals in phase 2 diets, while using dietary sources with better bioavailability values.

Acknowledgment

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