Effects of different iron, manganese, zinc and copper sources (sulphates, chelates, glycinates) on their bioavailability in early weaned piglets

(Einfluss unterschiedlicher Bindungsformen für Eisen, Mangan, Zink und Kupfer (Sulfate, Chelate, Glycinate) auf die Bioverfügbarkeit bei frühabgesetzten Ferkeln)

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Introduction

The regulated concentrations (EU1334/2003) for the trace elements Fe, Mn, Zn and Cu in compound feeds were reduced by 40 % except Cu when compared to the upper regulated limits before. The limited concentrations were still higher than the recommendations values but the safety bands were especially with regard to possible interactions with other feed compounds in the chyme lower than before. This becomes important especially for animals with high mineral requirements but low feed intake capacity like piglets in the first weeks after weaning. With regard to the abrupt change from high trace element absorbability during suckling to their relative low absorbability in compound feed the absorbability becomes a major limiting factor in mineral availability. The goal of this study was therefore to investigate the effect on mineral bioavailability (absorbability, performance, plasma concentrations) of three trace mineral sources (sulphates, chelates, glycinates) for iron, manganese, zinc and copper in restrictively fed weaned piglets after a 14-day-depletion period.

Materials and Methods

Forty early weaned piglets (24th day of age) were used from day 24 to 45 of age. The piglets were allocated pair wise in stainless steel pens, on body weight, gender and litter. For avoiding incomplete absorption all piglets were fed a basal diet (Table 1) with 14.1 MJ ME/kg and 192 g/kg of crude protein restrictively (0.77 MJ ME/kg$^{0.75}$) for the first 14 days after weaning which was formulated to meet the GfE requirements for piglets except iron, manganese, zinc and copper with concentrations of 48.0, 15.3, 24.6 and 3.8 mg/kg feed, respectively. In order to minimize possible interactions with phytate barley was heat treated (steam temperature 80 °C) prior mixing. Piglets had free access to drinking water containing 0.11, 0.008, 2.03 and 0.75 mg/l of Fe, Mn, Zn and Cu, respectively. After the depletion period pens were randomly allocated to 4 treatments: Control (no supplementation), sulphates, chelates (based on hydrolyzed soya) and glycinates (crystalline complexes). The three supplemented sources of Fe, Mn, Zn and Cu were included into the basal diet to reach 90% of NRC recommendations. Feed intake was similar across the treatments (0.77 MJ ME/kg$^{0.75}$).

Table 1: Basal diet formulation

Components		
Barley	%	53.0
Skimmilkpowder	%	37.4
Corn starch	%	3.0
Calcium carbonate	%	1.5
Cellulose	%	1.4
Soja oil	%	1.3
Mono-sodiumphosphate	%	1.2
Mineral-Vitamin supplementation	%	1.2

The analysed trace elements in the diets are given in table 2.

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Table 2: Analysed trace element concentrations (mg/kg feed) during the depletion and repletion period

Treatment	Fe	Mn	Zn	Cu
• Depletion period (24th to 37th days of age)	48.0	15.3	24.6	3.82
• Repletion period (38th to 44th days of age)				
- Control	48.0	15.3	24.6	3.82
- Sulphates	69.7	26.9	43.1	5.94
- Chelates	72.9	25.6	42.6	5.70
- Glycinates	68.2	27.5	44.4	6.18

The bioavailability was characterized mainly by apparent absorbability measured by adding Cr_2O_3 (0.5%) in diets fed during the 37th to 44th days of age. Faeces samples were collected by rectal sampling from each piglet at 24-h intervals during the last three days of the 8 day-repletion period. Additionally zootechnical performance (body weight gain, feed intake) was measured during the depletion and repletion period, as well as, haemoglobin and plasma concentration at the age of 44 days. Trace elements in feed, faeces, and plasma were analysed in accordance with the methods of VDLUFA (1988). All data were subjected to analyses of variance as completely randomized design. For treatment mean comparisons Sheffe`-test was used and significance level was set at $P \leq 0.05$.

Results and Discussion

The apparent absorbabilities of Fe, Mn, Zn and Cu are described for each treatment in table 3. In spite of the inhibition of phytases the mineral absorbability of trace minerals in piglets fed the control diet was relative low, which underlines the abrupt change from high to low absorbability after weaning. The means of mineral sulphates were not any better than those naturally found in the unsupplemented control diet. The chelates improved the mineral absorbability to sulphates by 19.4% in average, whereas differences of Mn and Cu were significant. The glycinates were even better with a 31.1% improved overall absorbability to sulphates, being significant for Fe, Zn and Cu. Compared to chelates Cu absorbability was significantly increased.

Table 3: Apparent absorbability of piglets at age 42 to 44 days (values in %)

Treatment	Fe	Mn	Zn	Cu
• Control	35.5 ± 7.7^{a}	36.1 ± 6.9^{ab}	38.8 ± 9.2^{a}	24.1 ± 7.0^{a}
• Sulphates	34.4 ± 5.5^{a}	33.0 ± 7.5^{a}	37.1 ± 6.7^{a}	26.0 ± 5.1^{a}
• Chelates	40.3 ± 4.9^{ab}	39.9 ± 5.0^{b}	42.2 ± 7.7^{ab}	31.4 ± 7.1^{b}
• Glycinates	41.8 ± 3.3^{b}	41.2 ± 3.8^{b}	46.0 ± 3.6^{b}	38.7 ± 5.5^{c}

Values with different superscript in the same column differed significantly ($P < 0.05$)

The haemoglobin status is presented in table 4. Probably due to the restricted feed intake and the limited duration of the study supplemented piglets were not able to increase their haemoglobin within the normal range of 12 g/dl. However, the supplementation of trace minerals permitted to improve the iron and copper status within 8 days above the critical 8 g/dl (anaemia). Sulphates and chelates increased haemoglobin numerically by 13.8 and 19.8%, respectively. With application of glycinates haemoglobin concentrations were increased significantly when compared to piglets fed the control or supplemented sulphate diet allowing piglets to have a nearly adequate level.

Table 4: Haemoglobin concentrations (g/dl) of piglets at age 44 days

Treatment	Control	Sulphates	Chelates	Glycinates
• haemoglobin	7.34 ± 2.06^{a}	8.35 ± 2.03^{a}	8.79 ± 1.21^{ab}	9.45 ± 1.13^{b}

Values with different superscript differed significantly ($P < 0.05$)

The blood plasma concentrations for Fe, Mn, Zn and Cu are given in table 5. Means were improved after supplementation with different sources of trace elements with an overall advantage (not significant) for organically bound Mn and Cu. However, with regard to Fe and Zn the concentrations after supplementation with organically bound elements were lower than those after supplementation with sulphates.

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Table 5: Trace mineral concentrations in blood plasma (µg/l) of piglets at age 44 days

Treatment	Fe	Mn	Zn	Cu
• Control	720 ± 28[a]	12 ± 10	1010 ± 300	1620 ± 270
• Sulphates	1290 ± 830[b]	13 ± 10	1210 ± 240	1760 ± 240
• Chelates	900 ± 280[b]	21 ± 20	1130 ± 340	1940 ± 290
• Glycinates	1210 ± 390[b]	22 ± 11	1160 ± 220	1910 ± 410

Values with different superscript in the same column differed significantly ($P < 0.05$)

The performance of piglets during the 8 day-repletion period is presented in table 6. The restricted feed intake for all treatments was in the range of 300 g per piglet and day. The use of dietary trace minerals tended to improved body weight gain and feed efficiency. Piglets supplied with organic trace minerals tended to perform even better than sulphates.

Table 6: Performance of piglets during the 8-day-repletion period at age 37 to 44 days

Treatment	Control	Sulphates	Chelates	Glycinates
• Body weight (kg)				
- Start	7,54 ± 0.81	7.62 ± 0.88	7.66 ± 1.33	7.58 ± 0.97
- End	9.54 ± 0.91	9.71 ± 0.90	9.80 ± 1.38	10.00 ± 0.94
• Body weight gain (kg)	1.90 ± 0.59	2.09 ± 0.31	2.14 ± 0.28	2.42 ± 0.05
• Feed efficiency*	1.383 ± 0.484	1.184 ± 0.193	1.149 ± 0.143	1.004 ± 0.022

* kg feed per kg body weight gain

Based on the method developed by Jongbloed et al. 2002 the overall bioavailability (relative factors for absorbability: 4; haemoglobin: 2; feed efficiency: 1) for chelates and glycinates relative to sulphates was 115 and 124 respectively. The higher potential for glycinates when compared to chelates was especially due to the improved absorbability of Cu.

Conclusions

Supplementations of either chelates or glycinates into basal diets to reach 90% of NRC recommendations for Fe, Mn, Zn and Cu after a 14-day-depletion period increased trace mineral absorbability, haemoglobin concentrations, as well as, growth performance and reduced faecal excretion when compared to sulphates and the unsupplemented control. Therefore the two tested organic trace mineral sources, especially the crystalline gylcinates could provide higher safety bands especially for animals with high mineral requirements but low feed intake capacity like early weaned piglets.

Reference

Jungbloed, A. W., Kemme P. A., De Groote G., Lippens M., Meschy F., 2002: Bioavailability of major and trace elements. EMFEMA, Brussels, Belgium.

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