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Institute of Animal Nutrition

Andreas Berk
Gerhard Flachowsky
Jürgen Fleckenstein

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Influence of supplemented Phytase on the Cu- and Zn-Content of pig carcasses

Berk A[1), Flachowsky G[1), Fleckenstein J[2)

[1)] Institute of Animal Nutrition, [2)] Institute of Plant Nutrition and Soil Science, FAL Braunschweig, Bundesallee 50, 38116 Braunschweig, Germany

Introduction

Zinc (Zn) and copper (Cu) are essential trace elements in the nutrition of plants and animals. In livestock production a deficiency of these elements can decrease animal performances and/or influence the health of animals (Mc Dowell 2003, Pallauf, 2003). Normally these elements are supplemented to compound feeds of livestock. In areas with a high livestock density, the excreted amounts of Zn and Cu lead to discussions of environmental problems (KTBL, 2002). This was the reason for the derivation of new upper limits of some trace elements in the EU recommendations valid from January 2004.

Especially when the supply of trace elements decreases because of environmental problems, the absorption rate (bioavailability) is of increasing interest. This bioavailability may be influenced by the phytate and/or phytase content of feed.

Material and Methods

50 carcasses from all castrated males (initial LW 25.5 ± 0.95 kg) from a trial with 100 growing-fattening pigs, (50 castrated males and 50 females) (Berk et al., 2003), were analysed to investigate the:

1. Influence of the level of Cu- and Zn-concentration in feed.
2. Influence of chemical binding form.
3. Supplementation of phytase (+700 units/kg feed) of microbial origin on Cu- and Zn-concentration in the whole body at about 115 kg LW.

There were three levels of feed concentration of the trace elements: native feed content only (7mg Cu/kg feed, 30 mg Zn/kg feed), and two levels of supplementation: (2 or 9 mg Cu/kg feed, Level 1, and 35 or 95 mg Zn/kg feed, Level 2) adequate to German requirements (GfE, 1987) and to the possible EU – upper levels.

The supplementations of Cu and Zn were given as sulphate ($CuSO_4$ and $ZnSO_4$) or as an amino acid – trace element – complex (AATEC).

All supplementation levels and trace element sources were added either with or without phytase (700 units/kg feed).
Consequentially, the design was created as shown in Table 1.

Table 1. Experimental design

Group	1	2	3	4	5	6	7	8	9	10
n	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*
Phytase	yes	yes	yes	yes	yes	no	no	no	no	no
Level	Native	1	1	2	2	Native	1	1	2	2
Source	Native	Inorg.	Org.	Inorg.	Org.	Native	Inorg.	Org.	Inorg.	Org.

*) 5 males/5 females

When reaching the slaughter weight of approximately 115 kg live weight (LW), these 50 animals were slaughtered, divided in the three fractions blood and offal (b+o), soft tissue, and bones of the left carcass half (corrected by the whole carcass weight). These fractions were analysed for DM, the contents of crude ash (CA), crude protein (CP), ether extract (EE) and of Cu and Zn.
Additionally liver, kidney and brain were analysed for DM and crude ash as well as Cu and Zn. The balances of the trace elements (Cu and Zn) were calculated on the basis of intake, the contents per kg LW, and the weight gain of the animals during the trial (from25.5 kg to 111.2 kg LW) in the course of the experiment.

Results and discussion

The results of the performance are given by Berk et al. (2003). The mean live weight gain (LWG) was 891 ± 65 g/day for all 100 pigs, or 895 ± 67 of the slaughtered 50 pigs. This performance could be considered as normal but on a high level.

<u>Analyses</u>

The phytase contents analysed are shown in Table 2.

Table 2. Phytase content of the groups (FTU/kg feed)

Group	1	2	3	4	5	6 - 10
	1310	1650	1890	1860	1180	290

The content of 290 FTU/kg of the non supplemented feed is normal, corresponding to a wheat, barley and corn-based diet. The partly extreme high contents of the supplemented diets are inexplicable, but without any influence on the experimental questions.

The intake of Cu and Zn varied, depending on the "native" level on the one hand and the "highly supplemented" level on the other hand, from 1360 mg Cu and 6344 mg Zn up to 3816 mg Cu and 29840 mg Zn, respectively. The mean intake was 2237 ± 675 mg Cu, respectively 16156 ± 7319 mg Zn, per slaughtered animal (Tab. 3).

Table 3. Mean intake of feed (88% DM), Cu and Zn per animal during the growing period

Phytase supply	n	Feed (kg)	Cu (mg)	Zn (mg)
Yes	25	221 ± 20	2206 ± 662	15936 ± 7236
No	25	228 ± 22	2268 ± 700	16375 ± 7543

Considering all three factors of influence, the total intake of Cu and Zn is given in Table 4. The significant differences are due to the experimental design.

Table 4. Mean intake of Cu and Zn

Factor		n	Cu	Zn
Phytase	yes	25	2206 ± 662	15936 ± 7236
	no	25	2268 ± 700	16375 ± 7543
Source	native	10	1583 ± 130^{B}	7034 ± 578^{B}
	SO_4	20	2575 ± 710^{A}	18857 ± 6795^{A}
	AATEC	20	2256 ± 588^{A}	18327 ± 6125^{A}
Level	native	10	1583 ± 130^{C}	7034 ± 578^{C}
	1	20	1816 ± 180^{B}	12439 ± 962^{B}
	2	20	2984 ± 368^{A}	24433 ± 2569^{A}

Tukey-Test, $p < 0.05$

Table 5. WBA of DM, CA, CP and EE (g/kg DM)

Phytase supply	n	DM	CA	CP	EE
Yes	25	405 ± 29	33 ± 2	149 ± 7	225 ± 33
No	25	413 ± 24	32 ± 2	152 ± 12	231 ± 31

Body Composition

There were no significant differences dependent on phytase supplementation in the whole body analysis (WBA) with regard to the contents of DM, CA, CP or EE (Tab. 5). The analyses of variance showed a significant influence of phytase for CA only (Pr > F = 0.044) for the criteria given in Table 4, and only a possible interaction of source x level (Pr > F = 0.035) for CP. The phytase supplementation led to significant differences in the amount of Cu in the fraction blood and offal (b+o), and the amount of Zn in the bones (Tab. 6).

Table 6. Influence of phytase supplementation on total amount of Cu/Zn (mg/animal)

Phytase supply	n	Soft tissue		Blood + offal		Bones	
		Cu	Zn	Cu	Zn	Cu	Zn
Yes	25	(49±10)	1161±112	25±3[B]	219±40	17±19	515±88[A]
No	25	(49±12)	1168±133	29±6[A]	203±24	11±5	434±110[B]

t-Test (p< 0.05); values in brackets means possible interaction phytase x source (Pr > F = 0.029)

Investigated Organs

It should be mentioned that in the case of the fraction b+o, the phytase supplementation lead to a lower amount of Cu and to higher amount of Zn. That is also true if comparing the contents of these trace elements in the liver (Tab. 7).

Table 7. Influence of phytase supplementation on Cu/Zn concentration in organs (mg/kg DM)

Phytase supply	n	Brain		Kidney		Liver	
		Cu	Zn	Cu	Zn	Cu	Zn
Yes	25	11±2	48±4	21±6[A]	94±11[A]	(20±4)[B]	213±80[A]
No	25	12±2	49±5	17±4[B]	85±11[B]	(27±10)[A]	169±51[B]

t-Test (p< 0.05); values in brackets means possible interaction phytase x source (Pr > F = 0.012)

No significant difference exists in the contents of both trace elements in the brain. But all other concentrations are significantly different. In the cases of Cu and Zn in the kidney, and Zn in the liver, the contents are higher if phytase is added to the feed. In contrast, in the case of Cu in the liver, the content is lower when phytase was added.

But an interaction was analysed for the source of supplementation. This could probably be a reason for these unexpected results. No significant differences in the trace element concentrations of organs were measured due to trace element source (Tab. 8).

Calculation of Balance

Especially the results of the kidney values indicate that there is an influence of absorption of nutrients, but in the case of Cu or Zn, the animals had no additional need and so these elements were excreted. Comparing the total balance of the whole body and the resulting excretion in the case of phytase supplementation, one can see that there is, in contrast to the values of the kidney investigation, a numerically higher balance of both elements. This consequently leads to a numerically lower excretion of both investigated trace elements (Tab. 9).

Table 8. Influence of source of supplementation on Cu/Zn concentration in organs (mg/kg DM)

Source	n	Brain		Kidney		Liver	
		Cu	Zn	Cu	Zn	Cu	Zn
Native	10	12±2	48±5	17±4	83±6	(23±5)	150±56
SO_4	20	12±3	49±4	20±7	91±15	(26±11)	197±69
AATEC	20	11±2	49±4	19±4	91±9	(22±5)	205±73

Tukey-Test ($p < 0.05$); values in brackets means possible interaction phytase x source (Pr > F = 0.012)

Table 9. Influence of phytase supply on Cu/Zn balance and excretion (mg/animal)

Phytase supply	n	Total amount		Balance		Excretion	
		Cu	Zn	Cu	Zn	Cu	Zn
Yes	25	91 ±25	1896 ±173	70 ±19	1456 ±139	2096 ±706	14480 ±7182
No	25	89 ±12	1805 ±205	68 ±9	1394 ±161	2200 ±701	14981 ±7469

t-Test ($p < 0.05$)

Table 10. Influence of level of supply on Cu/Zn balance and excretion (mg/animal)

Level	n	Balance		Excretion	
		Cu	Zn	Cu	Zn
Native	10	71±26	1311±163^{B}	1512±137^{B}	5723±499^{C}
1	20	68±11	1431±137^{AB}	1699±262^{B}	11008±944^{B}
2	20	69±11	1477±138^{A}	2915±365^{A}	22956±2500^{A}

Tukey-Test ($p < 0.05$)

The first level of supplementation of the trace elements Cu and Zn showed an insignificantly higher balance in the whole body of the investigated animals, but in the case of Zn, a significantly higher excretion. Only the second level led to a significantly higher balance of Zn, but a numerically lower balance in the case of Cu. The excretion of the second level is significantly higher for both elements of the native variant (Tab. 10).

In the case of Level 2, the excretion reached nearly double the level of the native groups (Cu), and actually double that of the first level groups (Zn) ($p < 0.05$).

Summary

The supplementation of phytase to cereals–soy bean meal–diets did not significantly influence pig performance of growing – finishing pigs from 25 to 115 kg LW ($p > 0.05$) (Berk et al., 2003). But the total balance of Cu and Zn is numerically higher, and the resulting excretion is numerically lower when phytase is added to the feed, because of the higher Cu (numerically) and Zn (significantly) amount in the fraction bones. The significantly ($p < 0.05$) higher amounts of Cu and Zn in the kidneys of animals supplemented with phytase indicate no effect concerning a higher transfer in the body tissue.

Like the performance data, the whole body analysis data showed clearly that the German recommendations (GfE, 1987) (Level 1) concerning Zn and Cu are safe enough to achieve a good health combined with high pig performance.

References

Berk A, Flachowsky G, and Fleckenstein J (2003): Effect of supplemented phytase at different Zn- and Cu- feed contents in pig nutrition, Proc. 9. Symp. Vitamine und Zusatzstoffe in der Ernährung von Mensch und Tier, 23./24. 09.2003, Jena, S. 210 - 215

GfE (1987): Energie- und Nährstoffbedarf landwirtschaftlicher Nutztiere – Nr 4 Schweine. DLG-Verlag Frankfurt/Main

KTBL (2002): Fütterungsstrategien zur Verminderung von Spurenelementen/ Schwermetallen im Wirtschaftsdünger, Proc. KTBL-Workshop, 23./24. 04.2002, Göttingen, KTBL-Schrift 410, 162 S.

McDowell LR (2003): Minerals in animal and human nutrition, 2nd ed., Elsevier, 644 p.

Pallauf J (2003): Zur Bewertung der Spurenelementversorgung in der Tierernährung, Proc. 9. Symp. Vitamine und Zusatzstoffe in der Ernährung von Mensch und Tier, 23./24. 09.2003, Jena, S. 13 - 25