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THE EFFECT OF PROLONGED SUPPLEMENTATION OF DIETARY ZINC ON WEIGHT GAIN, TISSUE STORAGE OF ZINC AND SOME SERUM VARIABLES IN FATTENING PIGS

By

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MARTINSSON, K. and L. EKMAN: *The effect of prolonged supplementation of dietary zinc on weight gain, tissue storage of zinc and some serum variables in fattening pigs.* Acta vet. scand. 1976, *17*, 279—285. — The effect of prolonged administration of dietary zinc in fattening pigs from 50 to 95 kg body weight was studied. No effect on daily weight gain was recorded. The concentration of zinc in different tissues did not increase. A slight increase of serum zinc was noted, but no other changes of the serum variables tested could be demonstrated. It was concluded that the amounts of zinc which are recommended for treatment of pigs with wasting syndrome do not introduce any significant accumulation of zinc in organs or tissues.

zinc; pigs; liver; serum; growth.

Since long time it has been established that zinc is an essential trace element for man and animals. The biochemical role of zinc has mainly been elucidated from studies on experimental zinc deficiency. In all species tested zinc deficiency is related to several metabolic impairments including a poor growth rate (*Reinhold* 1975).

The discovery of zinc in many purified enzymes has revealed the diversity of its function in protein and carbohydrate metabolism. It has been reported that zinc is associated with 59 known enzymes (*Reinhold*) and of these alkaline phosphatase (*Mathies* 1958) seems to have attended most interest.

Though there is a great number of investigations concerning zinc deficiency, only a few studies report on the effect of extra supply of zinc in animal nutrition. It was found by *Babatunde & Fetuga* (1972) that appetite and weight gain tended to be reduced at high levels of dietary zinc to pigs. However, in most tissues

the concentration of zinc did not increase. Administration of high levels of dietary zinc to beef calves for 3 months had no influence on weight gain (*Sommer et al.* 1975).

In Sweden nowadays addition of dietary zinc is often used as a therapy or supporting therapy in pigs which after weaning develop a wasting syndrome (*Martinsson & Ekman* 1974). In view of the relation of such treatments to the accumulation of zinc in certain tissues and consequently to public health a study on this effect of zinc seems important.

The aim of the present investigation was to study the zinc accumulation in different organs in fattening pigs after prolonged administration of increased supplementation of dietary zinc. Furthermore, the effect on weight gain and some serum constituents was investigated.

MATERIAL AND METHODS

A n i m a l s. Fattening pigs of a mean weight of about 50 kg at the start of the experiment were used. Twenty pigs, divided in 2 pens, with 10 pigs in each pen, received additional dietary zinc. Ten pigs in 1 pen were used as controls. The body weight of every pig was recorded at the start and the end of the experiment. The experiment continued until the body weight was about 95 kg when the animals were slaughtered.

F e e d i n g. All pigs received a commercial food used for fattening pigs in Sweden (Slaktsvin 290, Fors AB, Stockholm) containing 14 % protein, 0.7 % Ca, 0.5 % P and 10 p.p.m. Nitrovin. Both groups were given the same food since 4—5 weeks before the start of the experiment. In the experimental groups the drinking water was added with $ZnSO_4$ (125 mg/l H_2O). This corresponds to a mean daily addition of about 200 mg Zn calculated from the consumption of zinc sulphate and drinking water.

A n a l y s i s o f f o o d a n d w a t e r. The content of zinc in food was measured on an atomic absorption spectrophotometer after wet digestion of the samples with nitric acid. The concentration of Zn in drinking water was measured directly on the atomic absorption spectrophotometer.

B l o o d was drawn from the anterior vena cava at the start of the experiment and at slaughter. Blood serum was stored at

—20°C before analysis. The following methods were used for the analysis on blood serum:

Urea N. The Hyland UN-test (Hyland Div., Travenol Lab., Costa Mesa, Calif., USA).

Calcium, magnesium, zinc and copper. Atomic absorption spectrophotometer (Perkin-Elmer 403) according to methods recommended by the manufacturer (*Perkin-Elmer Manual,* March 1971).

Serum electrophoresis. Separation on cellulose acetate membranes in a Microzone R 101 with TRIS-buffer, pH 8.9. Evaluation in a Densitometer R 110 (Beckman, Fullerton, Calif., USA).

Alkaline phosphatase, aspartate aminotransferase (ASAT) and lactic dehydrogenase (LD). Methods recommended by the *Scandinavian Committee on Enzymes* (1974) using LKB Reaction Rate Analyzer and reagents from AB Kabi, Stockholm, Sweden.

Tissue samples.

After slaughter tissue samples were taken from liver, N. gracilis and the diaphragm (crus dexter) in all pigs. The samples were analyzed for Zn as described for the analysis of food.

RESULTS

No pigs showed any signs of illness during the experimental period. The groups of pigs receiving zinc sulphate in their drinking water had the same water consumption as the control group. The concentration of zinc in drinking water was about 4 mg/l before addition of zinc. The food given to all pigs contained 95 p.p.m. zinc. The daily food intake was not recorded but could be calculated to have been 2.0—2.6 kg per day. The daily weight gain during the experimental period was 0.78 ± 0.09 kg/day (mean $\pm$ s) and 0.83 ± 0.20 kg/day of the control pigs (Table 2).

The results of the analysis of blood serum are shown in Table 1. The concentration of serum zinc increased statistically significant from the sampling at the start of the experiment to the sampling immediately before slaughter. The increase was most pronounced in the zinc supplemented pigs. The difference of serum zinc concentration at slaughter between zinc supplemented

Table 1. The concentration of some serum components of the experimental and control animals at start and slaughter ($\bar{x} \pm s$). Significant differences between start and slaughter within each group marked as *, **, ***. Comparison of the two groups at slaughter are not marked in the table (see Results).

	Zinc. suppl. (n = 20)		Controls (n = 10)	
	start	slaughter	start	slaughter
Urea (mg/100 ml)	—	17.4±4.5	—	16.8±5.6
Ca „	11.6±0.7	11.1±0.6	11.4±0.5	11.8±1.0
Mg „	—	2.8±0.3	—	3.1±0.5
Cu (µg/100 ml)	194±24	250±23***	208±27	264±29***
Zn	100±11	135±15***	104± 7	122±12***
Alkaline phosphatase (u/l)	356±82	305±59	336±70	302±81
ASAT (u/l)	40± 9	79±61**	43± 7	100±37***
LD (u/l)	—	2050±1030	—	1710±350
Total protein (g/100 ml)	7.1±0.4	7.9±0.7***	7.0±0.5	8.2±0.3***
Albumin „	3.2±0.4	3.8±0.3***	3.3±0.3	4.1±0.2***
α-globulin „	1.1±0.2	1.2±0.2	1.1±0.1	1.2±0.1
β-globulin „	1.3±0.2	1.2±0.2	1.3±0.2	1.3±0.1
γ-globulin „	1.5±0.3	1.5±0.3	1.4±0.2	1.7±0.2**

pigs and controls amounted to only 13 mg/100 ml but was statistically probably significant. Several serum components investigated besides serum zinc increased in all pigs during the experimental period. Alkaline phosphatase showed a decrease. Serum albumin was slightly higher in the control pigs than in the zinc supplemented pigs at slaughter.

At post-mortem examination some pigs of both groups had moderate lesions typical of enzootic pneumonia. No other alterations could be observed.

Table 2. The concentration of zinc (mg/kg wet weight) in some tissues at slaughter ($\bar{x} \pm s$) and the daily weight gain during the experimental period ($\bar{x} \pm s$). No statistically significant differences are observed.

Group	Liver (mg/kg)	Musc. gracilis (mg/kg)	Diaphragm (crus dexter)	Weight gain (kg/day)
Zinc suppl. (n = 20)	57 ± 20	22 ± 5	29 ± 4	0.78 ± 0.09
Controls (n = 10)	46 ± 7	21 ± 4	30 ± 5	0.83 ± 0.20

The zinc content of the tissue samples are shown in Table 2. No significant differences between the zinc content of the tissue samples in zinc supplemented and control pigs could be observed.

DISCUSSION

Addition of dietary zinc is often used in Sweden as supporting therapy in weaned pigs or fattening pigs with a wasting syndrome. Addition of 150—250 g of zinc sulphate per ton of food or 5 g/20—40 l of drinking water is at present used for 10—20 days. Therefore there may be possibilities for a zinc accumulation in the tissues of interest from the view of public health.

In the present investigation the food contained about 95 p.p.m. of zinc, and the non-supplemented drinking water 4 p.p.m. The experimental pigs received an approximative addition of 200 mg of zinc daily via drinking water calculated from the water intake. It means that the daily intake of zinc was almost doubled compared to the controls calculated from a normal mean food intake daily of 2—2.6 kg during the experimental period.

The daily weight gain of the pigs was about the same in both groups (Table 2). This is in accordance with the findings of *Babatunde & Fetuga* (1972). These authors gave 0—500 p.p.m. of zinc daily from a live weight of 16 kg to final weight of 50 kg. They found that high doses of zinc (200—500 p.p.m.) tended to reduce appetite and weight gain though not significantly so and that addition of 100 p.p.m. gave rise to a minor increase in weight gain. Analyses of serum at the start of the present experiment showed no differences between the 2 groups of pigs. However, the concentration of several of the serum variables increased during the experimental period in both groups (Table 1). The serum concentration of zinc increased in both groups. The increase in the group supplemented with zinc was slightly greater than that in the controls. A minor influence of the zinc supplementation on serum zinc levels cannot be excluded. The levels of copper increased significantly, a finding which is difficult to explain.

The increasing concentration of total serum proteins and albumin in both groups during the experimental period is an effect of the increasing age (*Miller et al.* 1961). The levels of gammaglobulin are higher in the controls at slaughter compared to zinc supplemented pigs. Since no other lesions than enzootic

pneumonia were recorded, variation of its severity may be responsible for the differences in gammaglobulin levels.

A decrease of serum alkaline phosphatase is a classical sign of zinc deficiency. In this experiment there was a decrease in both groups which most likely is related to increasing age. The ASAT activities were much higher at slaughter than at the start of the experiment. A possible explanation is the stress and fighting before slaughter followed by muscular damage.

The analysis of zinc in tissues showed no significant differences between the treated and the control groups. These findings are in accordance with those of *Babatunde & Fetuga.* They found no consistent relation between increasing dietary zinc and the zinc levels of several tissues in pigs. The highest dietary levels in their experiment were 500 p.p.m. Similar results are also reported from studies in rats after prolonged dietary zinc supplementation of 600 p.p.m. (*Ansari et al.* 1975). In calves, however, addition of 600 p.p.m. zinc will increase the zinc levels of the liver about 700 % (cit. *Ansari et al.*). Therefore it seems likely that there are major differences in zinc metabolism and homoestatic control between different species. Regarding pigs and rats it may be suggested that increasing dietary zinc results in decreased net absorption. This assumption is supported by experiments in rats in which faecal excretion of both stable zinc and ^{65}Zn greatly increased after prolonged administration of high levels of dietary zinc (*Ansari et al.*).

From the results of the present investigation it can be concluded that addition of dietary zinc in the doses recommended in Sweden for treatment of pigs with wasting syndrome does not to any significant extent influence on public health.

Furthermore, it can be concluded that the amounts used do not increase daily weight gain provided no dietary zinc deficiency is evident. Therefore, addition of dietary zinc can only be recommended in pigs after confirmation of low serum zinc which is found in pigs with wasting syndrome (*Martinsson & Ekman* 1974; *Martinsson et al.* 1976). In such pigs an addition of zinc often has a clinical effect.

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SAMMANFATTNING

Effekten av kontinuerlig oral tillförsel av zink hos gödsvin på tillväxt, upplagring av zink i vävnader och några komponenter i blodserum.

Extra zink tillfördes via dricksvattnet till gödsvin från en ålder då levande vikten var 50 kg tills de slaktades vid en vikt av 95 kg. Medelintaget av extra zink beräknades till 200 mg/gris/dag. Ingen effekt på daglig tillväxt kunde konstateras i jämförelse med kontroller. Innehållet av zink i olika vävnader ökade ej i signifikant grad. En tendens till ökad zinkhalt i blodserum konstaterades. För övrigt noterades inga förändringar av undersökte serumkomponenter. Fynden diskuteras i relation till den intestinala mekanismen för absorption av zink. Det konkluderas att de mängder zink som idag rekommenderas som behandling av grisar med s.k. pelle-utseende ej medför några risker beträffande ackumulering av zink i organ och vävnader.

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