

# TREATMENT OF ZINC DEFICIENCY IN SHEEP BY ZINC CONTAINING BOLUSES

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## Summary

A study was conducted to investigate the release pattern of zinc from the zinc containing boluses and to see whether the released zinc can cure a zinc deficiency in sheep. Three sheep were used in this experiment and were fed a low zinc semi-synthetic diet throughout the experimental period. Each sheep was given a single pre-weighed zinc containing bolus when blood variables showed continuous zinc deficiency. The zinc containing boluses when placed within the reticulo-rumen of zinc deficient sheep, release zinc at the rate of 106.6 mg zinc/day for 39 days.

At the end of depletion period there was a reduced feed consumption, plasma zinc concentration, plasma alkaline phosphatase activity and increased plasma zinc binding capacity which were 409 g, 0.18 mg/l, 87 U/l and 88.7% respectively and 521 g, 0.18 mg/l, 142 U/l, and 89.5% respectively before first and second bolusing. After the administration of the first and second boluses, the feed consumption, plasma zinc levels and plasma alkaline phosphatase activities rose rapidly and far exceeded the starting values. The zinc binding capacity was reduced to 21.9% due to the administration of the first and second boluses. It is concluded that zinc boluses can be used for curing a zinc deficiency in sheep.

(Key Words: Sheep, Zinc Containing Bolus, Plasma Zinc Concentration, Plasma Alkaline Phosphatase Activity, Zinc Binding Capacity)

## Introduction

Several zinc deficiency in ruminants results in growth failure, poor feed intake, loss of wool, loss of hair around the eyes and mouth and inflammation of skin around the mouth, nose and eyes. All these defects have been observed by Ott et al. (1964), Mills et al. (1967) and Ho and Hidioglou (1977).

Various indirect and direct means exist for the prevention and curing of zinc deficiencies. The method of choice will vary with different animal species and feeding practices. The administration of zinc by oral dosing is one of the most reliable methods but requires daily repetition and therefore makes this method impractical on large scale.

The recent use of soluble glass as a vehicle for trace elements has been shown to be effective in preventing and curing deficiencies of copper, cobalt and selenium (Telfer et al., 1983). Zinc can also be incorporated into a soluble glass formulation for preventing or curing deficiencies (Knott

et al., 1985). Pilkington Brothers PLC (U.K.) St. Helens, England produced zinc boluses which contained 14% zinc by weight.

The objectives of this study were to investigate the release pattern of zinc from boluses and to investigate whether the zinc released cured sheep of zinc deficiencies.

## Materials and Methods

### Animal and management

Three two year-old (suffolk x Mule) sheep (two male and one female) were used in this experiment. The sheep were individually housed in a metabolism crate in a controlled environment house with a temperature of 19-21°C and light regime of 12 hours light and 12 hours dark.

The sheep were initially fed 1 kg/day of pelleted diet containing 33 mg zinc/kg DM for 60 days. Zinc deficiency was created (day 0) in the sheep by replacing 200 g of the pelleted diet each day for five days with a low zinc diet (table 1). The sheep were fed this low zinc semi-synthetic diet throughout the experimental period and distilled water was offered *ad libitum*.

### Treatment

Once sheep had become zinc deficient, each

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TABLE 1. THE COMPOSITION OF LOW ZINC SEMI-SYNTHETIC DIET

Ingredients	kg/100 kg
Corn flour	35.00
Dextrose	16.79
Wheat straw (milled)	10.00
Cellulose/solka floc	20.00
Egg albumin	6.00
Urea	3.00
Arachis oil (litre)	5.00
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	1.829
MgSO <sub>4</sub> ·7H <sub>2</sub> O	0.922
KHCO <sub>3</sub>	1.024
NaCl	0.391
	g/100 kg
FeSO <sub>4</sub> ·7H <sub>2</sub> O	19.17
CuSO <sub>4</sub> ·5H <sub>2</sub> O	3.675
MnSO <sub>4</sub> ·4H <sub>2</sub> O	16.24
CoCl <sub>2</sub> ·6H <sub>2</sub> O	0.404
KIO <sub>3</sub>	0.169
NaSeO <sub>3</sub>	0.066
Vit. A (3000 IU/kg)	0.600
Vit. D (360 IU/kg)	0.075
Vit. E (α-tocopherol)	2.500

Diet contained 2.18 mg zinc/kg dry matter.

sheep was supplemented zinc by giving a single pre-weighed zinc containing bolus by means of a balling gun on day 50 and again on day 154 these being times when blood variables showed a continuing zinc deficiency. The criteria used to define a zinc deficiency were that the zinc in plasma was less than 0.30 mg/l and the zinc binding capacity of plasma was greater than 70%.

#### Zinc release

Zinc balances were determined at regular intervals throughout the experimental period. As the calculated amount of zinc recovered from the boluses is significantly correlated with the rate of zinc release (Khandaker, 1987). The value of zinc release was estimated from the value of the calculated amount of zinc recovered. The calculated amount of zinc recovered was determined by subtracting the output of zinc in faeces and urine obtained pre-bolusing from the output of zinc in faeces and urine after bolusing. The number of

days that the bolus released zinc was determined as the point at which the balance after bolusing returned to the pre-bolusing level.

#### Sample collection and analysis

Zinc concentration of feed, faeces and urine was determined by atomic absorption spectrophotometry after digestion with the mixture of concentrated (Spectrosel grade) nitric, perchloric and hydrochloric acid (30, 20 and 10 by volume).

Blood samples were taken from the jugular vein and plasma was separated for analysis. Zinc concentration in the plasma was determined directly by atomic absorption spectrophotometry after diluting the plasma 1 to 4 with 0.1M HCl solution. The zinc binding capacity of the plasma was determined according to the method of Kincaid and Cronrath (1979). The alkaline phosphatase activity of plasma was estimated colorimetrically using para-nitrophenyl phosphate as a substrate at 39°C and it was expressed in U/l (Boehringer Mannheim GmbH cat no. 123 846).

SAS was used for student's t-test of data and SAS/GRAPH was used for plotting of data.

#### Results

##### Faecal zinc excretion

During the period of the zinc adequate diet, the average zinc excretion was 23.1 to 25.3 mg/day (figure 1). The faecal zinc excretion decreased to 2.5 mg/day 8 days after the introduction to the low zinc diet. These low levels (1.7 to 3.8 mg/day) were maintained until the administration of the first bolus (day 50). The faecal zinc excretion gradually increased and reached a peak value of 385 mg on day 59. However, high level of excretion was not maintained and gradually declined until it reached pre-bolusing levels between days 89 and 95. The low level (1.7 to 2.8 mg/day) of faecal zinc was again maintained until the administration of the second bolus on day 154. The faecal zinc excretion again started to rise and reached a maximum level of 268.7 mg/day, 5 days after the second bolusing. This high level gradually declined and reached pre-bolusing levels between days 188 to 196.

Table 2 summarises the total zinc that each bolus should have released in theory (expected) if it had completely dissolved and contrasts this figure with the calculated total recovery of zinc

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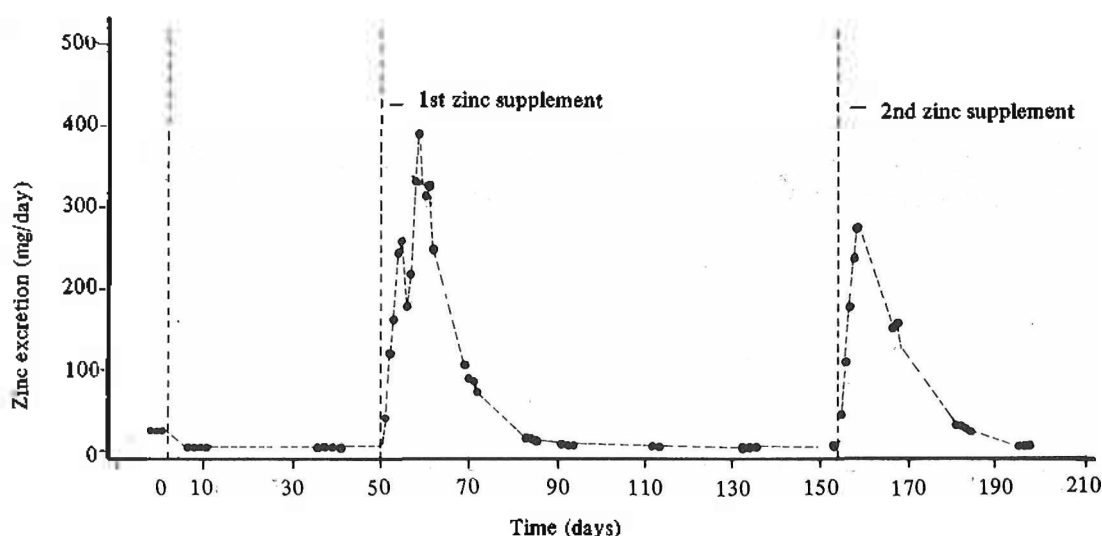


Figure 1. Faecal zinc excretion(mg/day) – average of 3 sheep.

TABLE 2. THE ESTIMATED LIFE TIME OF BOLUS, THE THEORETICAL RELEASE OF ZINC AND THE ZINC RECOVERED FROM THE BALANCES OF ZINC DEFICIENT SHEEP

Sheep No.	Weight of bolus administered (14% zinc)	Total zinc content of bolus	Theoretical release of zinc from the bolus (Total zinc/ No.of days)	Total zinc recovered from the balances	Estimated life time of bolus	Actual zinc release from the bolus (Total zinc recovered/ No.of days)
	(g)	(g)	(mg/day)	(g)	(day)	(mg/day)
A. First bolus						
1	33.93	4.75	139.7	4.79	34	140.8
2	32.71	4.58	101.8	4.54	45	100.9
3	33.43	4.68	111.4	4.06	42	96.7
B. Second bolus						
1	33.79	4.73	157.6	4.10	30	136.7
2	35.07	4.91	119.8	3.22	41	78.5
3	34.57	4.84	118.0	3.52	41	85.9
Average	38.8	4.75	124.7	4.0	38.8	106.6
	±2.3	±0.05	±8.3	±0.2	±2.3	±10.7

using the balance data obtained from the animals.

Statistical analysis (student's t-test) of the theoretical and calculated zinc release showed that these values were not significantly different.

## Feed consumption

The average feed consumption was 898 g of DM/day during the feeding of the high zinc diet. After the introduction of the low zinc diet, the

feed consumption gradually reduced to 409 g of DM/day at the end of depletion period. An increased feed consumption by the sheep was observed due to the first and second boluses (figure 2).

## Plasma zinc concentration

The average plasma zinc levels are illustrated in figure 3. The zinc concentration of the plasma

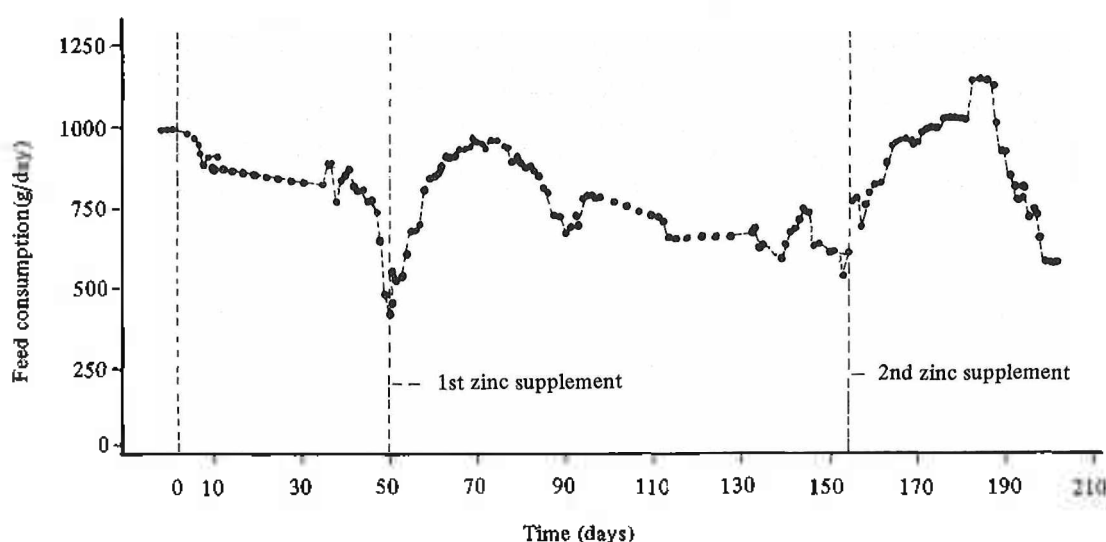


Figure 2. Feed consumption (g/day) — average of 3 sheep.

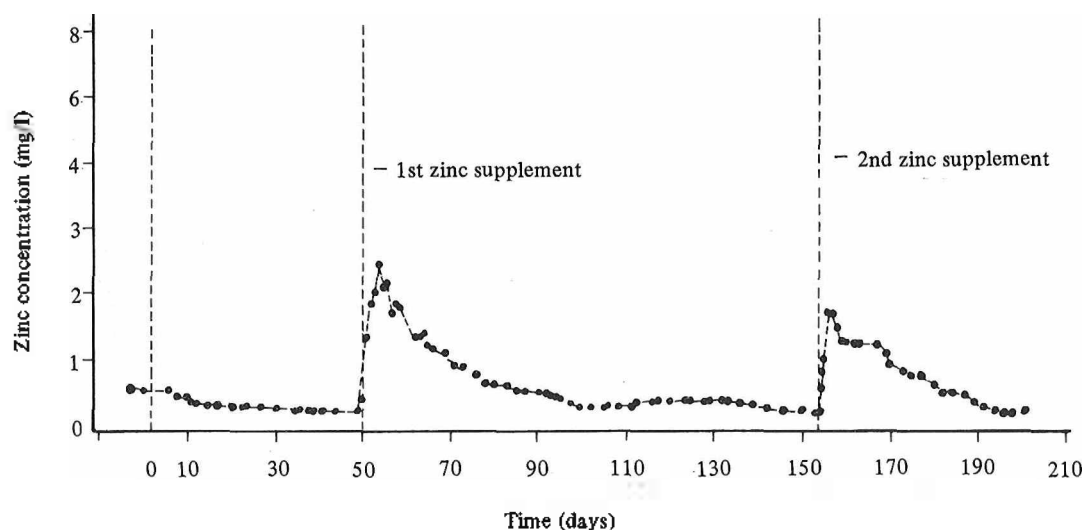


Figure 3. Plasma zinc concentration (mg/l) — average of 3 sheep.

was 0.53 to 0.58 mg/l before the introduction of the low zinc diet. There was a marked fall (from 0.58 to 0.18 mg/l) in plasma zinc concentration by the end of the depletion period. The abrupt rise of plasma zinc levels from 0.18 to 2.42 mg/l was observed by the 4th day after first bolusing. This higher level however, gradually decreased to 0.52 to 0.60 mg/l between days 83 to 86. The average zinc concentration above the pre-bolusing levels was maintained for more than 50 days and then returned to 0.18 mg/l on day 153. A further

rapid elevation of plasma zinc levels was also observed after the administration of second boluses.

#### Zinc binding capacity

The zinc binding capacity of plasma was increased from 66.1 to 88.7% at the end of depletion period and this level was markedly reduced to 21.9% on the 9th day after first bolusing (figure 4). Thereafter a slow rise was observed and a level of 66.8% was reached at 85 days and

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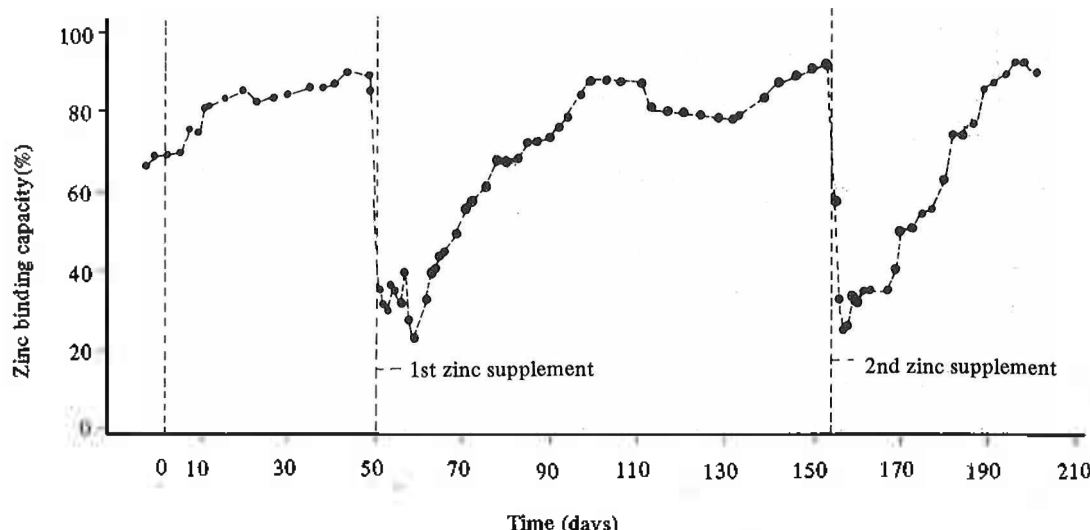


Figure 4. Plasma zinc binding capacity (%) — average of 3 sheep.

then increased to 89.5% before the second bolusing. This level was sharply reduced to 24.6% 3 days after the second bolusing (day 157) and started to rise with time until it reached pre-bolusing levels.

## Alkaline phosphatase activity

The average alkaline phosphatase activities gradually decreased from 203 to 87 U/l by the end of the depletion period (figure 5). This low level was sharply increased from 87 to 225 and 142 to 300 U/l by 4 days after the first and second bolusing respectively. The higher levels were almost maintained for more than 39 days before starting to fall again.

## Discussion

The sheep used in this experiment were first fed a diet containing 33 mg zinc/kg DM and then fed a low zinc diet. The aim of feeding the low zinc diet was to deplete them of their body stores of zinc.

The results of this experiment have showed that the average feed consumption was reduced after the introduction of low zinc diet and then subsequently increased after the administration of the first and second boluses. This result is in accordance with the finding of Ho and Hidirolou (1977) who reported that the feed consumption was significantly increased when zinc defi-

cient calves and lambs were given supplementary zinc.

The average plasma zinc level was 0.18 mg/l before the administration of the first and second boluses indicate that all sheep were in a zinc deficient condition before the giving of the first and second boluses. The administration of zinc containing boluses increased in plasma zinc concentration and the increased levels were maintained for more than 42 days.

The zinc binding capacity of plasma was 66.1% before introduction of low zinc diet and was increased to 88.7 and 89.5% respectively by the end of the depletion periods. These levels fell to 21.9, 23.4% respectively by 3 days after the administration of the first and second boluses. Normal levels (60 to 70%) were then maintained for more than 28 days. Kincaid and Cronrath (1979) also showed that supplemental zinc to zinc deficient calves greatly reduced the zinc binding capacity of plasma.

The decreased in alkaline phosphatase activity of plasma was most likely reflects in zinc deficiency. Figure 5 illustrated the rapid increase in alkaline phosphatase activity of plasma when first and second boluses were given to zinc deficient sheep. Master and Moir (1980) also reported that supplemental zinc greatly increased the alkaline phosphatase activity of plasma.

The total daily faecal zinc excretion showed that the zinc excretion was higher than pre-bolus-

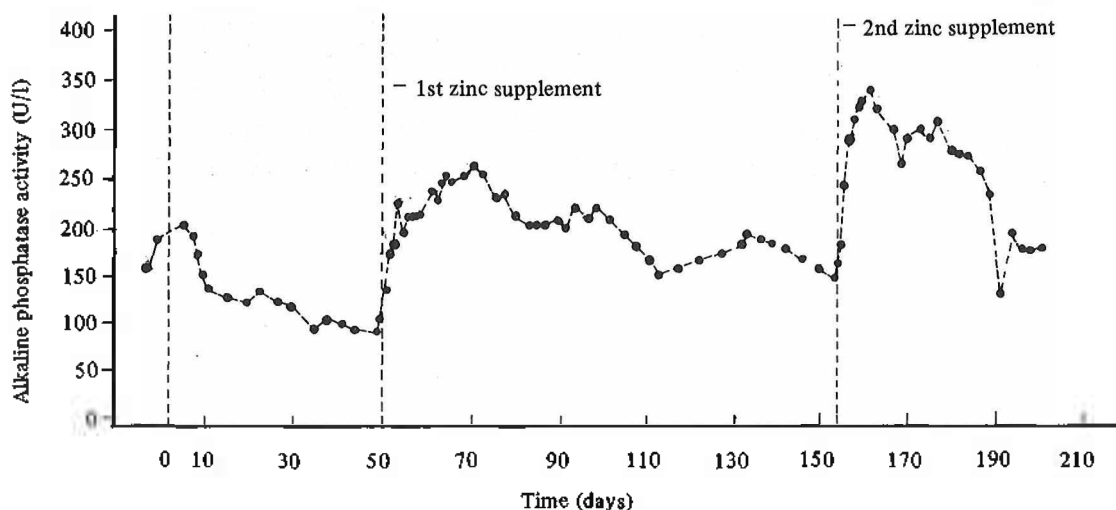


Figure 5. Plasma alkaline phosphatase activity (U/l) — average of 3 sheep.

ing levels for 36 to 45 days after the first and second bousing. Faecal zinc consists mostly of unabsorbed dietary zinc with a small amount of endogenous origin being secreted into the small intestine (Miller, 1969). Suttle et al. (1982) reported that the endogenous faecal losses were remarkably constant despite a wide range of zinc intakes. Animals fed on a zinc deficient diet had a lower endogenous faecal losses, this endogenous losses being further reduced when the animals developed clinical zinc deficiency (Miller, 1969). Therefore, in the present experiment, most of the faecal zinc would be attributable to unabsorbed zinc released from the boluses and passed out in the faeces.

The theoretical zinc available from the boluses was 124.7 mg/day and this compares to the actual recovery of zinc using the balance data of 106.6 mg/day. The zinc recovered from the boluses on the sheep showed that there were some variation in the zinc, released from the individual boluses. This variation is likely to be due to different dissolution rates of the boluses due to the variation between the animals. Small differences could be expected due to variations in condition in the melting, annealing and cooling process and for boluses made at different times under laboratory condition. However, in spite of the various factors that may affect the dissolution rate it was found that there were no significant differences between the theoretical values (expected) and calculated

(recovered) values. These results therefore indicate that the zinc containing soluble glass boluses completely dissolve when lodged in the reticulo-rumen of sheep.

It is concluded that the over all zinc status of the zinc deficient sheep was improved as shown by the zinc dependent variables. Therefore, zinc containing boluses can be used for the curing of zinc deficient symptoms and this type of supplementation needs to be repeated for every 40 days.

#### Acknowledgements

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