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Some lessons from using zinc-salt treatments to protect dairy cows against facial eczema

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Abstract

A trial at AgResearch Ruakura, evaluating two different methods of administering zinc⁺⁺ (Zn) salts to protect cows from facial eczema, was carried out in lactating dairy cows to study the variation in concentrations of blood Zn⁺⁺. The treatments were: continuous supply of zinc sulphate (ZnSO₄) through water troughs (n = 10 cows), versus daily oral drenching with zinc oxide (ZnO) (n = 10 cows). Responses in daily milk yields, and concentrations of Zn⁺⁺ in blood were recorded twice weekly over four weeks for each cow. The ZnSO₄ trough treatment took ten days for blood Zn⁺⁺ concentrations to equilibrate, after which the sampling-day average ranged from 20–26 µmol/L. Between-cow repeatability was 0.42 ± 0.15. The daily ZnO treated cows equilibrated after drenching for three days. Average blood Zn⁺⁺ concentrations then ranged from 24–29 µmol/L. Between-cow repeatability was 0.44 ± 0.17. Daily milk yields did not differ significantly between treatments. Target ranges for blood Zn⁺⁺ concentrations to provide protection against facial eczema in lactating dairy cows of 18–34 µmol/L were published 26 years ago. These may need to be re-assessed, with changes in breed composition and increases in milk yield over that time within the national herd.

Keywords: zinc; facial eczema; dairy cow

Introduction

Facial eczema (FE) is caused by the saprophytic fungus (*Pithomyces chartarum*), which grows on decaying pasture in New Zealand's North Island, generally in late summer and autumn. The fungus produces a toxin, sporidesmin. Primary symptoms of the disease in susceptible ruminants are liver and bile duct injury, which may also lead to secondary skin or hide damage, particularly on light-coloured areas of the body. Hence the common name of facial eczema for the disease.

Four management methods are available to protect dairy cows from an FE challenge, namely avoid toxin-affected pasture, reduce the challenge to animals on toxin-affected pastures, protect animals grazing on toxin-affected pastures, and a long-term solution of protecting the animal by breeding and genetic selection against susceptibility to the toxin.

The objective of this project was to study the effectiveness of two versions of the second management method of protecting the animals grazing a toxin affected pasture, by administering zinc (Zn) compounds. The two treatments compared were administration of: zinc sulphate (ZnSO₄) supplied through a water trough and daily administration of zinc oxide (ZnO) by oral drenching.

The experiment was set up to examine the uptake of Zn⁺⁺ in quantities sufficient for FE protection of cows under field conditions. Administration was timed to be completed before the natural FE season. Success of either experimental treatment was defined as reaching a minimal threshold blood Zn⁺⁺ concentration, as animals were not challenged artificially with the FE toxin or with toxin in the field. The unsupplemented levels of circulating Zn⁺⁺ ranged in these cows from 9 µmol/L to 13 µmol/L. The required Zn⁺⁺ threshold and target ranges in dairy cows

were taken from recommendations by Smith (1987) as 18 µmol/L to 34 µmol/L.

Materials and methods

Trial design

The trial was carried out with the approval of the AgResearch Ruakura Animal Ethics Committee: Approval No. 11665.

The experiment involved cows from the AgResearch Dairy Herd No 1, beginning on 13 January 2009 (Day 0), before the natural FE season. Twenty lactating dairy cows were randomly divided into two treatment groups of ten cows each. On Day 0 one group was supplied with ZnSO₄ in their drinking water for four weeks. The other group was orally drenched daily with a suspension of ZnO. Dosing rates used for ZnSO₄ and ZnO were as recommended by the suppliers and by DairyNZ (2010).

Cows of similar genetic background and environmental experience were allocated to both groups. Paddocks for the trial were partitioned into two with temporary electric fencing, so that initial feed quantity/cow and quality, but not water supply, were balanced as far as possible across the two treatments. Cows grazed *ad libitum*, and were moved to a new partitioned paddock as necessary. Due to declining pasture availability in the trial, silage was introduced from Day 20 to supplement the pasture allocation.

Details of ZnSO₄ treatment. ZnSO₄ was administered at the rate 0.8 g of ZnSO₄.7H₂O per L of water. This concentration supplied 40 g heptahydrate/cow/d, at 8 g heptahydrate /100 kg cow live weight/d, with an estimated daily water intake of 50 L/cow estimated as 10% of live weight for a 500 kg cow. A masking agent (Grapple, Agri-feeds, Mount Maunganui, New Zealand) was added to the Zn⁺⁺ solution, to make it palatable. The 0.8 g/L was

Table 1 Least squares mean \pm standard error of blood and production parameters for each of the two Zn⁺⁺ administration treatments over four weeks.

Parameter	Zn ⁺⁺ administration treatment		P value
	Trough	Daily drench	
Number of cows	10	10	
Blood Zn ⁺⁺ concentration ($\mu\text{mol Zn}^{++}/\text{L}$)	23.9 \pm 1.6	26.2 \pm 1.5	0.29
Daily milk yield (L/d)	14.7 \pm 0.4	14.9 \pm 0.4	0.70
Initial live weight (kg)	486 \pm 16	477 \pm 15	0.69

Table 2 Repeatability \pm standard errors for cow measurements across days within the two Zn⁺⁺ administration treatments over four weeks for blood Zn⁺⁺ concentration and daily milk yield.

Parameter	Zn ⁺⁺ administration treatment	
	Trough	Daily drench
Number of cows	10	10
Blood Zn ⁺⁺ concentration ($\mu\text{mol Zn}^{++}/\text{L}$)	0.42 \pm 0.15	0.44 \pm 0.17
Daily milk yield (L/d)	0.29 \pm 0.13	0.39 \pm 0.14

increased to 1.5 g/L by the end of the trial, allowing for habituation, and lower than expected early water intakes. The trough was not connected to the water supply, but was filled at intervals with water and heptahydrate of the appropriate concentration.

Details of ZnO treatment. ZnO was administered as a slurry that was made up fresh each day by mixing 130 g ZnO with 350 mL of water. This was equivalent to 13 g ZnO/cow, for a 500 kg cow. The ZnO slurry was stirred until lump-free, and mixed again immediately before drenching. The slurry was administered at the rate 35 mL/cow at afternoon milking, thereby avoiding any difficulty in interpreting blood Zn⁺⁺ concentrations in morning blood sample results.

Measurements. Milk yield in litres was recorded for each cow automatically, at each milking, twice a day, using the Ruakura Integrated Milk Harvester. Cow live weight was recorded on Day 0 of the trial. Those allocated to ZnO oral drenching had a live weight mean of 478 kg compared with the ZnSO₄ group who had a mean live weight of 495 kg. Blood serum samples were obtained twice weekly from the tail of each cow by vacutainer, for analysis of Zn⁺⁺ concentration.

Measurements of daily maximal temperature, and total 24 hour rainfall were obtained from the National Institute of Water and Atmospheric Research's records for Hamilton at a site approximately 10 km from the experimental area.

Statistical analyses

Ten cows per treatment were sampled for statistical analysis. Least square means for live weight at Day 0 were obtained from analysis of variance (SAS 2012), fitting fixed effects for two treatment groups and two age groups of three years of age and four

years of age and older with a covariate for the number of days in milk.

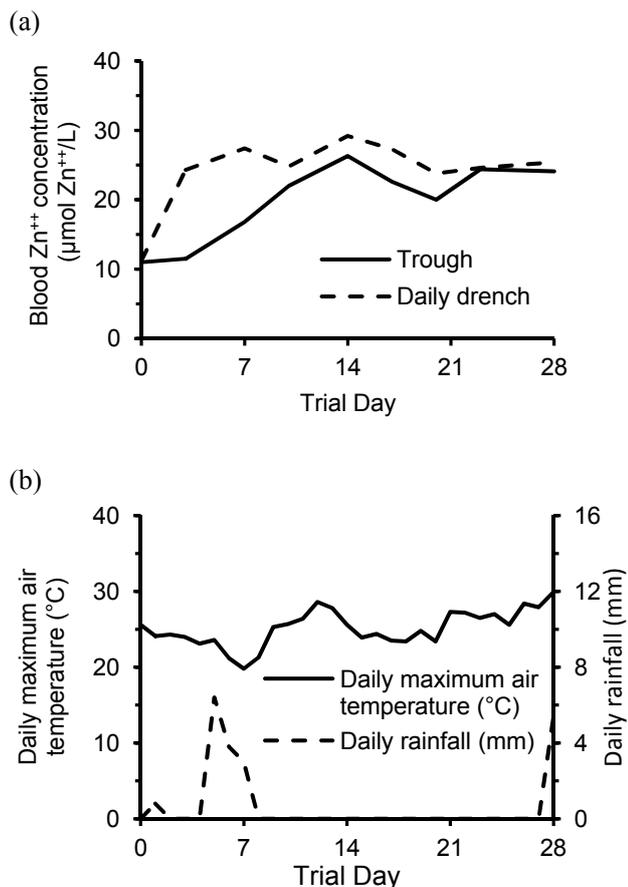
The trough-treated cows took about ten days for blood Zn⁺⁺ concentrations to equilibrate. Consequently only data from sampling on Days 10, 14, 17, 20, 23 and 28 were included in the least squares analysis of blood Zn⁺⁺ concentration. As the daily-drenched cows equilibrated after about three days sampling on Day 3 and Day 7 were included for this treatment. To account for repeated sampling, the random effect of cow and the fixed effect of sampling day were added to the model for blood Zn⁺⁺ concentration and daily milk yield, together with a covariate for live weight at Day 0.

A restricted maximum likelihood (REML) programme (Gilmour et al. 2009) was used to estimate repeatabilities for blood Zn⁺⁺ concentration and daily milk yield, among cows within treatments, using a repeated-animal model. Fixed effects were similar to those described above. Effects which were non-significant ($P > 0.05$) were dropped, and the revised model was re-run. Repeatabilities of blood Zn⁺⁺ concentration were estimated separately for cows on the two treatments, as there was no prior expectation that the estimates would be similar.

Results

Blood Zn⁺⁺ concentrations at Day 0, before treatments began, ranged from 9 $\mu\text{mol/L}$ to 13 $\mu\text{mol/L}$ and daily milk yield at Day 0 averaged 14.9 and 15.2 for trough treatments and drenching treatments, respectively. During the trial period there was variability in the average blood Zn⁺⁺ concentrations between the highest and lowest cows within treatment, by a factor of 1.5 and 2.6 for trough-treated and drenched cows, respectively. This variability was

Figure 1 (a) Treatment effects on blood zinc⁺⁺ concentration, and (b) daily maximum air temperature and daily rainfall during the four week treatment period.



despite including a masking agent with the trough treatment and a fixed daily dose of ZnO for the drenched cows. There was a delay of up to ten days in equilibrating blood Zn⁺⁺ concentrations in the trough treatment due to lower than expected water intakes and a delay of up to three days in the drench treatment.

The least squares means and standard errors, after fitting fixed effects and covariates, are shown for measured traits, after equilibration, in Table 1.

There were no significant differences ($P > 0.05$) between the treatment groups for blood Zn⁺⁺ concentration, daily milk yield or initial cow live weight. The least squares means indicate that trough treatment was not significantly different from daily drenching for increasing circulating blood Zn⁺⁺ concentration. There was a significant repeatability (Table 2) for cows on the trough treatment (0.42 ± 0.15) and a similar significant repeatability for the drenched cows (0.44 ± 0.17). Daily milk yields were less repeatable for the trough treatment (0.29 ± 0.13) than for the cows subjected to the ZnO drenching treatment (0.39 ± 0.14).

Times to reach an equilibrium blood Zn⁺⁺ concentration are shown in Figure 1(a). Daily maximal air temperature, which ranged from 22°C to 28°C, and daily rainfall, where a total of 4.7 mm fell during the treatment period, are shown in Figure 1(b).

Discussion

In contrast to earlier experimental work when dosing was with ZnSO₄ (Towers & Smith, 1978), the present trial involved ZnO dosing as is now recommended in commercial herds for animal-safety reasons (Smith et al. 1977).

It appeared that many dairy farmers were taken by surprise in the serious FE season of 2008 with inadequate protection of their herd against FE using a zinc⁺⁺ treatment. Advice in the industry is that ZnSO₄ trough treatment provides inadequate protection in a serious FE season. This advice appeared to have been ignored in 2008, or was administered too late. Thus the two commonly used treatments of ZnSO₄ trough treatment and ZnO drenching were compared in 2009 to assess their effectiveness at raising serum Zn⁺⁺ levels.

Smith et al. (1983) used ZnSO₄ at dose rates of 0.35 g Zn⁺⁺/d as zinc heptahydrate for 36 days, and found this gave sufficient protection against FE. Higher dose rates than that are now recommended, with long-term treatment being recommended (DairyNZ, 2010), depending on the season and fungal spore growth.

Our trial results confirmed that serum Zn⁺⁺ was elevated consistently by both treatments. The repeatability from cow to cow over time with ZnO drench was moderately high at 0.44 showing that those cows with, for example, higher than average concentrations, repeatedly had higher than average concentrations, even when receiving the same daily quantity of drench.

There was no significant difference in serum Zn⁺⁺ concentration between treatments, but drenching clearly was more labour-demanding. In Figure 1, the two treatment lines never crossed, over the period of the trial. This apparent difference may be critical for FE protection in years with severe FE seasons. Thus trough treatment in such seasons may need to be monitored closely.

A 'reference range' for serum Zn⁺⁺ concentration in lactating cows is available from veterinary laboratories (Smith, 1987), with 9 µmol Zn⁺⁺/L to 20 µmol Zn⁺⁺/L regarded as 'Normal' in unprotected cows, and 18 µmol Zn⁺⁺/L to 34 µmol Zn⁺⁺/L representing animals under 'Facial Eczema control'. However, the background to the 18 µmol Zn⁺⁺/L and 34 µmol Zn⁺⁺/L range, with a mean 26 µmol Zn⁺⁺/L, was a preliminary recommendation in 1987. It is evident from Table 1 that a mean Zn⁺⁺ concentration of 26 µmol Zn⁺⁺/L was not achieved with ZnSO₄ supplementation at the dose rate used. In view of the changes in breed composition and increases in daily milk yield in the dairy industry, in the 26 years since (DairyNZ, 2012), the 'reference range' may need to be revisited in a larger or longer-term experiment with a FE challenge.

Although only a short-term protection, ZnO drenching was not significantly superior to ZnSO₄ trough treatment. However, equilibration time with

ZnO drenching appeared to be earlier, although the drenching practice itself was time-consuming. Subsequent work to look for a long-term solution for FE, by making animals FE-resistant by breeding, has investigated the enzyme gamma-glutamyltransferase (GGT) after natural challenge in industry herds with pedigree information (Cullen et al, 2011). GGT, which is a repeatable trait from year-to-year, has provided the opportunity to select genetically resistant animals, which would need neither method of protection with Zn⁺⁺ against FE.

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