Cyanide Decay in Feratox® Cyanide Capsules

by
Dale McEntee
Steve Hix
and
Shaun Ogilvie

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Cyanide decay in Feratox® cyanide capsules

Dale McEntee1
Steve Hix2
Shaun Ogilvie1

PREPARED FOR:
Connovation Ltd, PO Box 58613, Greenmount, Auckland

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1Bio-Protection and Ecology Division, Lincoln University, PO Box 84, Lincoln.
2Connovation Ltd, PO Box 58613, Greenmount, Auckland
1. Executive Summary

Aim

- To investigate the rate of decay in cyanide concentration of Feratox® cyanide baits

Methods

- Seven Feratox® capsules were placed in vials of water and their condition monitored over 13 days. Six of the seven Feratox® capsules were split into two groups for total cyanide tests
- The cyanide concentration and condition of Feratox® capsules was measured over a 23 week period. Capsules were exposed to two feed paste treatments; a commercially available paste (FP) and a custom mixed Feratox® paste (CP)

Results

- The cyanide concentration in capsules from both treatments fell gradually over 77 days, from 50 mg/capsule to approximately 35 mg/capsule
- The variation in the assay results was similar for the days 15, 24 and 43, however on day 77 variation was large
- Capsule outer appearance ratings matched well with assay results (FP, $r^2 = 0.98$, CP, $r^2 = 0.84$)

Discussion and Recommendations

- The cyanide decay appeared to be roughly linear over a 77 day period, with the only difference between the treatments occurring on day 43. However variation in the cyanide concentration increased markedly on day 77 which limits interpretation
- The duration and temporal pattern of cyanide loss differed from that recorded by Warburton et al (1995)
- A field study with the Feratox® capsules in the feed paste is needed to compare with the laboratory results
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2. Introduction

Small vertebrate pests such as possums, rodents, mustelids and rabbits are routinely poisoned using toxins such as sodium monofluoroacetate (1080), brodifacoum, pindone, cholecalciferol, and cyanide (Innes & Barker, 1999). Feratox® is a pea-sized vinyl encapsulated cyanide capsule. It is intended to be more effective than cyanide paste and reduce the risk of exposure to hydrogen cyanide gas for the users (Eason et al., 2001). Desirable aspects of Feratox® are its rapid and humane action, biodegradable, low secondary poison risk, and it does not accumulate in the food chain (Warburton et al., 1995). If the vinyl cyanide capsules are exposed to moisture, brown spots appear on the capsule indicating that the potassium cyanide is beginning to hydrolyse into hydrogen cyanide. This is a naturally occurring chemical reaction between cyanide and water, as follows: \( \text{CN}^- + 2\text{H}_2\text{O} = \text{NH}_3 + \text{HCOO}^- \). Warburton et al., (1995) showed that capsules exposed to moisture in leaf litter remained fully toxic for 1 month before showing a decline over the next 8 weeks. Warburton et al., (1995) suggest that the loss of potassium cyanide (KCN) must be as a result of the integrity of the coating being breeched by moisture, as cyanide loss occurred despite no visible flaws or fractures in the capsules. This is the attribute of the Feratox® capsule which we think could be exploited to create a ‘programmable bait’, that is bait where it is possible to manipulate the length of time for which it is toxic. The Feratox® capsules are embedded in the Ferafeed® (a specially formulated feed paste) and then fed to possums using bait delivery devices. The most common of which are plastic bait stations and small bait bags (Thomas et al., 2003). Feratox® has become the industry-accepted method for cyanide baiting (Thomas et al., 2003). The rate of cyanide loss from Feratox® capsules in feed paste was determined in a controlled lab environment. The outer appearance of capsules was rated in order to compare it with the cyanide concentration.
3. Methods

3.1 Cyanide loss in feed paste

The cyanide is encased in a vinyl capsule intended to make the cyanide safer to handle and prevent moisture getting to the cyanide. The bait itself is a thick paste. To make the bait one layer of paste is ‘poured’ (involves scooping some feed paste out of the bucket and pressing it into the bottom of the potato starch tray). The cyanide capsule is placed onto the first layer of paste in the potato starch tray and a second layer of paste is ‘poured’ on top (Figure 1). There were two treatments of feed paste. One commercially-available paste (FP) used with cholecalciferol and Feratox® poison, where the water content comes from the margarine in the paste, and another custom mixed Feratox® paste (CP), which uses a different type of margarine and where water was added with the intention of having a high moisture content. There were 162 Feratox® capsules in each treatment (54 potato starch trays/3 baits per tray).

![Figure 1. Bottom = Empty potato starch tray. Middle = One layer of feed paste ‘poured’ and the three Feratox® capsules added. Top = With the second layer ‘poured’.](image-url)
On 24<sup>th</sup> August 2005 the potato starch trays of bait were ‘poured’ and put in sealed bags. Three bags were needed for each treatment. These bags were placed alternately standing on their sides in a sealed bucket. The baits were checked after 15 days then on days 19, 24, 28, 43, 57, 77 and 166. After 15 days, 10 baits from each treatment were checked to see if any ‘spotting’ (dark brown or black spots on the capsule, indicating cyanide hydrolysis) was evident. A graduated scale from one to ten was used to assess the degree of this spotting, one being the first signs of spotting, ten being an almost entirely black capsule which had also softened. This rating was the observers’ subjective opinion on the condition and the same observers were used throughout. When half of the baits exhibited spotting, three samples were sent away for cyanide testing. Each sample contained three capsules, as three were required for the laboratory to conduct the test. After 15 days all 20 capsules between both treatments showed signs of spotting, so samples were sent to Hill Laboratories for analysis then and subsequently on days 24, 43 and 77. Ratings of the appearance of capsules were taken on these days and also on days 19, 28 and 57. The results from the total cyanide assays and the outer appearance ratings are presented. Regressions of the cyanide assay results against the outer appearance ratings were also constructed. SigmaPlot 8 was used for all analyses.

To prevent deterioration, samples were stored in sealed bags and chilled or frozen in transit to the laboratory.

### 3.2 Cyanide loss in water

On 24<sup>th</sup> August 2005 seven Feratox® capsules were placed in small individual glass vials. These vials were filled to approximately eight tenths with tap water and capped. Over the following thirteen days the capsules were checked 10 times and examined for evidence of ‘spotting’ (darkness on the capsule indicating cyanide hydrolysis), the colour and amount of ‘spotting’.

At the end of the 13 days six of the Feratox® capsules were split into two groups and sent to Hill Laboratories for total cyanide tests. Three capsules had little or no sign of breakdown and three appeared to have significant change and cyanide loss. The three capsules that appeared to have undergone significant change and possibly cyanide loss
were placed into a separate group from the capsules that appeared unchanged (capsules 3,6,7 and 2,4,5).

### 3.3 Moisture content of the feed paste

The formulation of the feed pastes which were used did not allow for certainty in the water content of the paste, therefore we measured the water content of the feeds. First volumetrically using a hydrosense probe, with the metal prongs of the probe entirely embedded into the paste six times and a reading taken. This was done for two custom mixed feed pastes (high (CP) and low water pastes) and the commercial paste (FP). Water content was also measured gravimetrically shortly after the setup day in an attempt to confirm the hydrosense result. This test was conducted only on the CP and FP pastes.
4. Results

4.1 Feratox® in Feed Paste

The cyanide concentration in capsules from both treatments fell gradually over 77 days. The cyanide concentration in the CP treatment was significantly lower on days 43 and 77 than on days 15 and 24. No significant difference could be found in the cyanide levels for the FP treatment. The FP treatment had significantly higher cyanide concentration than the CP treatment on day 43. The variation in the assay results was similar for the days 15, 24 and 43. However, on day 77 each treatment had one value very different from the other two which accounted for the large confidence interval (Figure 2.). Although the paste treatments were intended to have different water contents it appears to be approximately 8% for both treatments (Figure 6, Figure 7). Throughout the experiment the temperature increased as we moved from spring into summer (Figure 8) and humidity decreased (Figure 9).

![Figure 2. Decrease in total cyanide concentration in Feratox® capsules in Commercial (FP) and Custom (CP) baits. Each point represents the mean of three assay tests which each required three capsules. CI = 95% N = 3.](image-url)
The deterioration of the outer appearance of the CP capsules was significantly higher than the FP capsules on days 43 and 57. Before and after these dates no significant difference occurred (Figure 3). This result is similar to the assay result where the only significant difference occurred on day 43 (Figure 2). The deterioration of the capsule appearance occurred gradually, with no period deteriorating much faster than any other (Figure 3).

![Graph](image)

**Figure 3.** Outer appearance ratings of the capsules, showing the increase in deterioration of the appearance of Feratox® capsules in both feed paste treatments. Between days 15 and 24 N=10, thereafter N=15.

In the FP treatment the average rating of degradation given to the capsules in a sample proved to be a very good predictor of the total cyanide assay result ($r^2=0.9799$) (Figure 4). This is also the case for the CP treatment, although the relationship is weaker ($r^2=0.8364$) (Figure 5).
Figure 4. Assay result for total cyanide against the average rating those three capsules were given for deterioration of appearance, in the commercial paste (FP) treatment.

Figure 5. Assay result for total cyanide against the average rating those three capsules were given for deterioration of appearance, in the custom paste (CP) treatment.

4.2 Feratox® in Water

The feed coating on the vinyl capsules deteriorated and usually fell off the capsules within four days, however in one case it took 7 days. Three capsules showed little <5% or no discolouring of the vinyl capsule. In three capsules it appeared that the cyanide was deteriorating as the capsules took on a reddish brown hue. One capsule broke apart after 12 days revealing white cyanide (i.e no discolouring). The assay results indicated that the cyanide had broken down in both the capsules showing deterioration signs (10.9 mg/capsule KCN) and those with no indication of cyanide breakdown (14.8 mg/capsule KCN).
5. Discussion and Recommendations

The results showed that cyanide loss does occur in Feratox® capsules, in both water and feed paste. The loss of cyanide in the two feed paste treatments appears to have been consistent over the 77 day period, with the only significant difference occurring on day 43 where the cyanide content was significantly lower (95% CI) in the CP treatment. This pattern of Feratox® breakdown differs from that reported in Warburton et al (1995), where the persistence of cyanide in Feratox® capsules was tested for capsules exposed to moisture in forest leaf litter. Warburton et al (1995) observed an initial stable period (one month) followed by rapid cyanide loss to near zero after three months. This difference may be indicative of the variable environmental conditions the capsules were susceptible to in the leaf litter. Changes in the moisture present in the leaf litter may have caused the differences in breakdown of the Feratox®. In the present experiment the moisture the Feratox® capsules were exposed to came from the feed paste. The experiment was run in a controlled environment and it is expected that there was little change in the amount of moisture any given capsule was exposed to over time.

During the first month no significant differences were recorded between treatments in either the outer appearance or the total cyanide assay results. During the second month the FP capsules were in better condition and retained more cyanide than the CP capsules. After day 57 there was no significant difference between the treatments.

The results suggest that the condition of capsules can be used as a rough guide to the amount of remaining cyanide (Figure 4 & 5). However even when capsules appeared severely degraded, rating average 8+, the total cyanide concentration was still approximately 30 mg/capsule. Also this only works in the feed paste because capsules in water don’t show any black spotting. In water the only significant change in appearance was the loss of the thin green outer coating on the capsule. Some capsules appeared to become slightly reddish brown. It was hypothesised that this was because of the cyanide changing colour within the capsule as it deteriorated. However, when the capsules were split according to those that had shown this slight change in colour and those which hadn’t the cyanide concentration was approximately the same, 14.8 mg/capsule KCN and 10.9 mg/capsule KCN, respectively.
In summary, Feratox® capsules will definitely lose cyanide in water and in a feed paste that includes water. However the signs that can be used to indicate cyanide loss are different in feed paste than in water. The capsules in feed paste become black and lose their integrity, signs which when rated approximated the total cyanide amount. The loss of cyanide in the feed paste was approximately linear, however the high variation on day 77 limits interpretation of these results. The capsules in water exhibit little sign with which to predict the cyanide concentration. The results suggest that the breakdown of Feratox® capsules varies for reasons including but not exclusively the substrate they are used in. More understanding of the Feratox® capsules breakdown is needed before baits could be ‘pre-programmed’ to be toxic for a specific length of time.

It is recommended that these results need to be compared with a field study to see if the rate of cyanide loss in Feratox® capsules is significantly affected by external conditions.
6. References


Appendix 1  Moisture content results

Figure 6. Results of the gravimetric test of water content. CI = 95% N = 2.

Figure 7. Results of the volumetric test of water content. CI = 95% N = 6.
Appendix 2  Temperature and Humidity

Figure 8. Half-hourly temperature readings throughout the experiment.

The mean temperature was 22.04 with a standard deviation of 1.79 and the range was 16.38 to 27.12. We can see that as we went from spring into summer the temperature increased as expected. It appears unlikely that temperature change has had much of an effect on our results.

Figure 9. Half-hourly humidity readings in the bucket throughout the experiment.

The mean humidity was 66.5 with a standard deviation of 2.98 and the range was 29.9 to 73.9. However the low results are when the experiment was being checked and under normal conditions the humidity in the bucket was always higher than 60%. Humidity
was slightly higher during spring, and this is to be expected. Humidity is an important
determining factor in cyanide breakdown so it is important to be aware of it. In our
experiment it was fairly consistent for long periods and is unlikely to have significantly
altered the results.