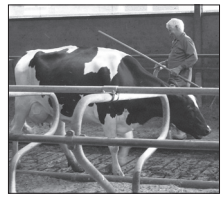
Appendix Chapter 7



Concentration of formalin in walk-through footbaths used by dairy herds

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Introduction

Healthy claws are of great importance to the cow's optimal productivity, health and animal welfare (Brand et al., 1996), with lameness is foremost associated with claw-problems (Weaver, 2000). Epidemiological research on claw disorders in dairy cattle indicates that digital and interdigital dermatitis are the main infectious claw diseases (Somers et al., 2003). Since the use of antibiotics in footbaths is banned in The Netherlands, many farmers are using chemical disinfectants in footbaths like copper sulphate, zinc sulphate, formalin and combinations of these for the prevention and treatment of (infectious) claw-problems. Because copper and zinc solutions may cause environmental problems, formalin footbaths are recommended (Toussaint Raven, 1989), despite disadvantages such as irritation of the conjunctivae and epithelium of the respiratory tract of the herd personnel. This type of footbath, comprising a 4% formalin solution in water (made from 37 per cent formaldehyde) and used for 3 consecutive days, especially the walk-through baths, has been used for 15 years, despite the changes in herd management and the more than doubling of the average herd size. To be effective, the formalin concentration must remain at or above 2 per cent (Penna et al., 2001).
The aim of this study was to calculate and measure the advised footbath initial concentration (4 per cent formalin) and to estimate the 50 per cent decrease (≤ 2 per cent) in formalin concentration (half concentration time [t1/2]) in walk-through footbaths by sampling each one immediately after the last dairy cow had passed through.

Material and methods

Between December 2000 and September 2001, 18 dairy farms (average herd size 66.8 animals, range 40-140 animals) with cubicle housing, slatted floors and a walk-through footbath, were visited by personnel from GD Ltd., Deventer on three consecutive days. During the first visit, the personnel calculated the capacity (m^3) of the bath based on length x width x height, and counted the number of animals passing through. The footbath was filled to a depth of 120-

150 mm with tap water and a formalin disinfectant (Delco® Form; Kleencare Hygiene B.V.) until a 4 per cent concentration was reached, according to the farmer's calculation. The footbath was homogenised by the personnel, who also took a sample after preparation by the farmer to measure the initial formalin concentration before any cow had passed through. Thereafter, the footbath was sampled six times immediately after each milking. Before taking a sample, the height of the bath contents were checked to make sure it was not less than 100 mm and the contents of the footbath were homogenised.

On each farm the footbath was situated in the exit lanes along the cows' route from the milking parlour to the free stall barns. The cows walked through the footbath twice a day, and then kept on scraped floors. The animal's claws were not systematically cleaned before passing through the footbath and the baths were not refilled during the study.

To prevent contamination due to organic particles, for example faeces, sawdust and so on, samples taken were filtered before storage and to minimise possible gas production, the bottle was filled completely. To prevent further reduction of the formaldehyde concentration by reacting with other compounds present in the solution, 1 ml methanol was added to the filtered sample. The samples taken in the morning were delivered to the laboratory for further analyses within two to three hours, and the evening samples were stored at room temperature and delivered the next morning (after 14 to16 hours).

The method used to determine the formaldehyde concentration was developed in the laboratory at GD Ltd. Using gas-chromatography, the present components in the samples were separated at an apolair capillary column and were quantified with a flame-ionisation with an auto sampler. This method was validated for the field study, before the experiment. This included the production of para-formaldehyde and the theoretically possible conversion of para-formaldehyde in formaldehyde during the analysis. These phenomena were checked by the method developed for analyses and were not observed.

Statistical analysis

The data were analysed (Sigma Plot for Windows 4.01, SPSS Inc.) and t1/2 was calculated using the equation:

$$y = f(a \times e^{(-bz)}),$$

where y is the formalin concentration (per cent) and z is the time since preparation of the bath. The other symbols (a, b and f) are constants based on the results. The t1/2 was calculated using stata's pk commands (Stata Corp 2001). The elimination rate, K, was calculated as the negative of the parameter estimate for a linear regression of the decrease in concentration in relation to log time (minutes). From this K, t1/2 was calculated as ln2/K. Subsequently, a linear regression was performed to check whether t1/2 was significantly affected by the initial concentration, the size of the bath (in litres), the number of cows passing through it and the number of litres per cow passing through.

Results and discussion

The size of each footbath and the number of cows passing through the bath after milking are shown Table 1.

Table 1. Volume of formalin in each footbath and the number of cows passing through.

Herd	Contents of bath (l)	Number of cows passage of the bath
1	200	40
2	400	51
3	600	50
4	370	60
5	270	65
6	382	64
7	240	57
8	168	65
9	200	50
10	930	100
11	257	58
12	170	58
13	160	73
14	290	85
15	110	140
16	150	62
17	144	40
18	131	85

There was no change in the depths of the baths on each farm. Table 2 shows the formalin concentrations measured in the different samples at the six samplings.

Table 2. Formalin concentration (per cent) in relation to the number of herd passages after preparation of the footbath.

	No. of herd passages							t1/2
Herd	0*	1	2	3	4	5	6	(min.)
1	0.9	2.7	2.2	1.7	1.4	1.1	0.8	1929-3
2	1.9	2.6	2.7	2.3	2.1	1.8	1.6	3685-6
3†	1.8	3.1	3.1	3.1	2.7	2.8	2.9	
4	6.5	6.9	6.5	6.3	6.4	6.2	5.1	4374-7
5	9.6	3.3	3.2	3.0	2.8	2.6	2.4	6230-0
6†	2.0	1.2	1.6	1.3	1.8	2.2	2.1	
7	4.3	3.8	3.5	3.3	3.0	2.1	2.3	3898-3
8	3.2	2.6	1.9	1.0	1.0	0.7	0.4	1086-0
9	1.8	3.4	3.1	2.8	2.9	2.4	2.3	4291-1
10	3.4	2.6	2.1	1.5	0.9	1.0	0.8	5435-8
11	3.8	3.7	3.5	3.2	3.0	2.0	2.4	4745-0
12	2.7	2.8	2.2	2.4	1.9	1.7	1.4	3186-3
13	4.0	3.4	2.8	1.6	1.1	0.3	0.5	1286-6
14	5.5	5.0	3.9	3.4	2.6	2.3	1.7	2324-3
15†	5.5	3.3	1.7	1.0	0.5	0.1	0.8	
16	2.5	2.6	2.2	1.9	1.6	1.5	1.2	3434-6
17	5.0	4.7	4.3	3.7	3.4	3.0	2.4	2841-3
18	4.5	3.5	2.9	2.0	1.4	1.2	1.0	2980-2

* : Pretreatment concentration

† : No t½ due to irregular concentration pattern

t½ : Half-concentration time

Because of the great variation estimated at time 0, the concentration of formalin at the first herd passage was considered to be the initial concentration. In 11 of the 18 samples an initial concentration of above 3 per cent was measured. In 6 of these, the concentration was still above 2 per cent after six passages. Figure 1 shows the formalin concentrations related to the time of sampling.

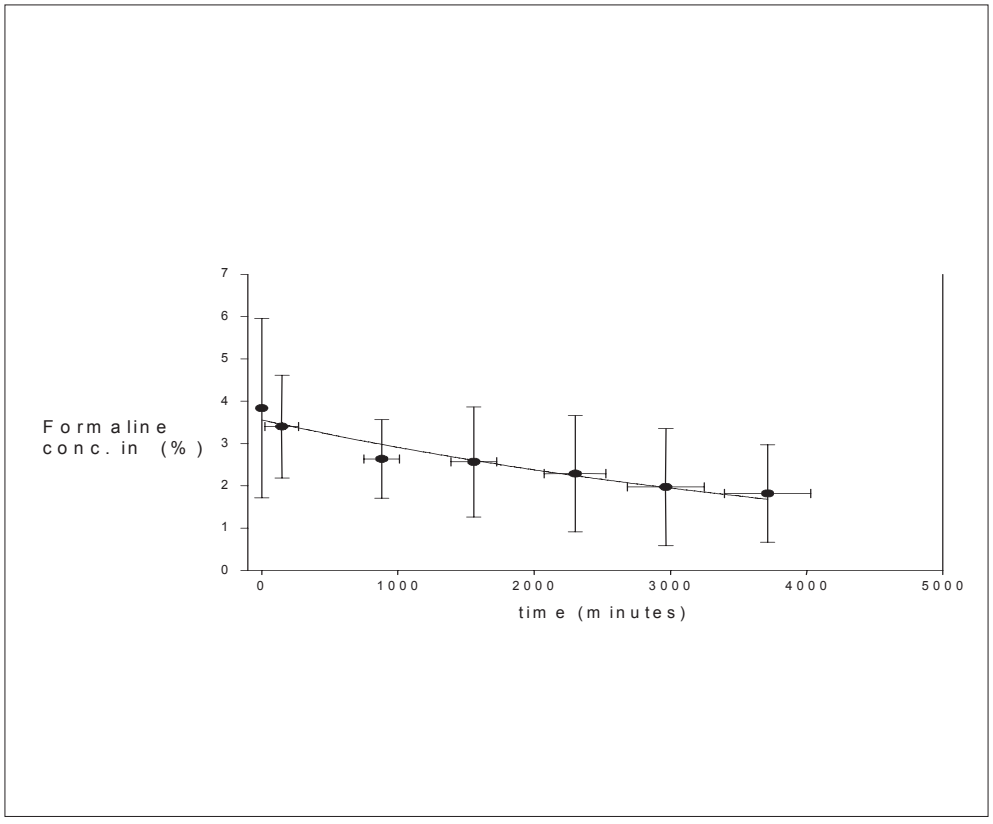

Figure 1. The mean (SD) formalin concentration in the footbath in relation to the time after preparation (in min.).

The average estimated t1/2 was 3449 minutes (range 1086 to 6230 minutes, median 3435 minutes). The software excluded herds 3, 6 and 15 due an irregular concentration pattern. Further analysis on the remaining herds showed that the initial concentration and the numbers of cows passing through each time had no significant effect on t1/2. The size of the bath (in litres) and the number of litres per cow passing through it were highly correlated (r=0.86). In separate analyses, both showed a positive effect (P= 0.05) on t1/2. The size of the footbath (range 131 to 930 litres) increased t1/2 by 3.74 minutes per litre, and the number per litres per cow (range 0.8 to 12) increased t1/2 by 357 minutes per unit.

This field study shows that there is a large variation in the initial concentration of formalin in footbaths. The differences in the concentrations of formalin in the

samples taken immediately after preparing the bath (Table 2) could be due to an inexact amount of formalin being supplied to the footbath, miscalculations by the farmer who prepared the bath and/or insufficient mixing of the contents of the footbath. It was considered that the mixing in the bath was complete after one passage of the cows (Table 2).

In this study the average herd size was 66.8 cows. Based on the recommended 4 per cent concentration and a 50 per cent decrease in the initial concentration after 2.40 days this corresponds with 300-320 cow passages. The decrease in formalin concentration over time is in agreement with the results of Berry and Maas (1997), in which it was also advised to refresh a footbath after 200 to 300 passages. This means that, under normal conditions in The Netherlands, where the average herd size is 57 cows (CBS, 2002), a footbath should be refreshed at least every two days (four herd passages) to guarantee sufficient activity, that is a formalin concentration of above 2 per cent. In addition, any 10°C temperature increase in air temperature in the housing will result in a two- to three fold increase in the evaporation of formalin (Anon, 2004). It is advisable to pay attention to this phenomenon in further studies.

The recommended minimum concentration of 2 per cent formalin is based on Toussaint Raven (1989) and in the literature, a 2 per cent concentration disinfection is recommend for the disinfection of all kind of apparatus (Penna et al., 2001). Information on MIC90 or MIC50 values for bacteria like *Treponema spp.* or *Dichelobacter spp*. for formalin would be necessary for proper advice on the prevention and treatment of claw infections. Unfortunately these data are not yet available, due to the bacteria are not being cultured easily (R. Walker, personal communication).

An effective walk-through footbath must have a minimum size of 300 cm length, 80 cm width and 15 cm height. Fifty percent of the footbaths (for example herds 8, 12, 13 and 15; Table 1) were too small in relation to the number of cows; that is, they were too short (mostly) or had insufficient height or were too shallow. It was remarkable that, in all the baths, the amount of fluid stayed the same; a decreasing amount of fluid would have been expected after each cow passage, but any spilt solution was probably replaced by manure, urine and dirt.

The large variation in the reduction of the footbath concentrations may be related to the cleanliness of the claws at the start of the footbath and the

number of cattle defecating in the bath. In The Netherlands it is uncommon to place two footbaths in tandem, with the first containing water or a mild detergent solution for cleaning the claws (e.g. Blowey, 1993). However, a dual footbath may be preferable, where the claws may be cleaned in the first bath and then disinfected in the second which is more effective with less influence on the concentration of the solution.

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