Evaluation of Three Commercial Hoof-Care Products Used in Footbaths in Danish Dairy Herds

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ABSTRACT

Digital dermatitis is a serious problem in dairy production in many countries. Footbaths have been used extensively for the prevention and cure of digital dermatitis. But there is a lack of scientific evidence regarding the effectiveness of hoof-care products used in footbaths. The objective was to evaluate 3 commercial hoof-care products in 12 Danish dairy herds (testing each product in 4 herds) using a controlled clinical trial. One-half of the herds were conventional and the other half was organically managed. The hoof-care products represented the 3 main groups of active compounds currently legal in Denmark [glutaraldehyde (Virocid), organic acids (Kickstart 2), and quaternary ammonium compounds (Hoofcare DA)]. A split footbath was used, with one side of the cow treated and the other side as a negative control. In each herd, 100 cows were selected randomly. All digital dermatitis lesions were recorded during hoof trimming at the start of the study. The mean prevalence of active digital dermatitis lesions on the hind legs was 21.8 and 22.7% for treatment and control sides, respectively. All cows walked through the footbath 2 d/wk for 8 wk. After 8 wk of treatment the cows were examined again and all lesions were recorded. In each herd, the percentage of cows was calculated with active digital dermatitis lesions at the start of the study that were cured during the study period (termed percentage cured) and the percentage of cows with new infections during the study period (termed percentage new infections). Percentage cured ranged from 13.6 to 100, and percentage new infections ranged from 0 to 35.5. For all hoof-care products, the difference between treatment and control sides was not statistically significant. Overall, there was no effect on percentage cured or percentage new infections for any of the tested hoof-care products.

Key words: hoof-care product, digital dermatitis, footbath, dairy cow

INTRODUCTION

Digital dermatitis is a serious problem in dairy production in many countries including Denmark. The disease has been reported worldwide (Laven and Logue, 2006). Digital dermatitis causes pain and lameness in infected cows, thereby negatively affecting animal welfare (Rodriguez-Lainz et al., 1999; Laven and Proven, 2000). Digital dermatitis may cause reduced milk production in affected cows (Cooke and Bennett, 2005; Losinger, 2006). Nevertheless, Warnick et al. (2001) did not find a negative effect of digital dermatitis on milk production.

Footbaths were used extensively to control infectious hoof disorders including digital dermatitis (Laven and Proven, 2000; Laven and Hunt, 2002; Laven and Logue, 2006). Copper sulfate was traditionally used in footbaths (Laven and Logue, 2006). In Denmark, antibiotics are not licensed for use in footbaths and copper sulfate has been the “product of choice” for many years for the prevention and cure of digital dermatitis. However, since September 1, 2006, copper sulfate has been illegal for this use in the European Union (EU) because of an EU biocide directive (Anonymous, 2006). Therefore, Danish and other European dairy farmers now have a need for alternative hoof-care products that are scientifically proven to be effective. Evaluation of the effectiveness of several legal hoof-care products could help dairy farmers, veterinarians, and consultants decide which strategy to use in their digital dermatitis management programs.

In a recent review, Laven and Logue (2006) concluded that there was a lack of scientific evidence regarding the effect of hoof-care products used in footbaths. They stated that there were few peer-reviewed reports of the effectiveness of treatment regimens. Additionally, in a significant proportion of peer-reviewed articles on the subject, the references to treatment were anecdotal or were limited to response rates, with few details of materials and methods. To our knowledge, only 1 study has evaluated a nonantibiotic hoof-care product against a negative control in a single herd of 44 cows (Manske et al., 2002).

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Our objectives were to evaluate the effect of 3 hoof-care products used in commercial dairy herds on 1) the cure of existing digital dermatitis lesions, and 2) the prevention of new digital dermatitis lesions. Our hypothesis was that one or more of the tested hoof-care products would have a positive effect on the cure or development of digital dermatitis due to their antimicrobial activity.

MATERIALS AND METHODS

After evaluating the list of hoof-care products approved by the EU biocide directive (Anonymous, 2007), most products contained 1 of 3 key compounds as their active ingredient: glutaraldehyde, quaternary ammonium compounds, and organic acids. One product was randomly selected from each of these 3 groups. The products were Virocid (used at a concentration of 1.5% water, main active compounds: glutaraldehyde, didecylmethylammoniumchloride, and alkyldimethylammoniumchloride; Cid Lines, Ieper, Belgium), Hoofcare DA (concentration 2%, main active compounds: quaternary ammonium compounds; DeLaval, Drongen, Belgium), and Kickstart 2 (concentration 1%, main active compounds: hydrogen peroxide, acetic acid, and peracetic acid; Cid Lines). Concentrations and frequency of use were as suggested by the manufacturers.

Each of these products was tested in 4 commercial dairy herds; 2 herds were conventional and 2 were organic. Twelve herds were selected that fulfilled the following inclusion criteria: >100 cows, a loose-housing system with freestalls, cooperative farmer, and digital dermatitis was identified as a problem in the herd by the local veterinarian or agricultural consultant. Additionally, to avoid cows walking through the footbath more than twice daily, herds with automatic milking systems were not included. All included herds milked cows twice daily. Ten of the herds had mainly Danish Holstein cows and 2 herds had mainly Danish Red dairy breed. Average milk yield per cow year was 8,891 kg (range: 7,465 to 10,854 kg) and the average herd size was 166 cows (range: 106 to 255). The hoof-care product used in the individual herds was selected randomly.

A split footbath was used with a negative control. The split footbath allowed treating one side of the cow (e.g., left fore leg and left hind leg) and use of the other side as a negative control. The side of the cows to be treated was selected by systematic random sampling, thereby ensuring that 2 of the 4 herds within each hoof-care product were treated on the left side only and 2 herds were treated on the right side only. The footbath had a length of 230 cm. The treatment side was filled with the hoof-care product solution at a depth of approximately 20 cm and the control side contained nothing.

The control side might have contained pure water, but this would have increased the possibility of cross contamination with bacteria between cows. Additionally, the water might have meant a cleaning of the hooves. This, in turn, might have had a positive effect on hoof health. The middle third of the footbath consisted of a metal grate that reduced the fecal contamination of the solution in the footbath. Feces from cows that defecated when walking through the footbath in most cases did not contaminate the solution, but instead fell through the grate onto the floor.

Initially, sample size calculations were performed. The efficacy measures used for the sample size calculation were the proportion of cows cured during the study period and the proportion of cows with new infections during the study period. To demonstrate a statistically significant difference in effect of 50% between the treatment and the control side, a sample size of 231 cows for each product was needed (assumptions: 1-sided test, proportion of legs affected with digital dermatitis set at 0.2, significance level 5%, and power 80%; Toft et al., 2002). Based on these calculations, 100 cows were randomly selected in each herd. The cows had hooves trimmed at the start of the study and all digital dermatitis (DD) lesions on all 4 legs were recorded in the hoof trimming box using the scoring system developed by Manske et al. (2002) as shown in Table 1. All observations were made by agricultural technicians from the University of Aarhus, Faculty of Agricultural Sciences. The technicians had several years of experience with clinical observations on dairy cows and were trained in the use of the scoring system during a pilot project. The technicians were blinded in relation to which side of the cows was treated and which hoof-care product was used in the herd. During the second evaluation of the cows, the technicians had no information about the DD status of individual cows at the first evaluation.

All cows walked through the footbath 2 d/wk with 2 to 3 d in between (immediately after leaving the milking parlor after the morning and afternoon milking) for 8 wk. If the herd consisted of >100 cows, the hoof-care product solution was renewed after passage of 100 cows. The renewal of the solution after passage of 100 cows was decided upon in collaboration with the companies supplying the hoof-care products as they all stated that fecal contamination could inactivate the hoof care products.

After 8 wk of treatment, all 100 cows that remained in the herd and were available for examination were taken to a hoof trimming box and DD lesions were scored again. The study period was January to June 2007. In 10 of the herds, all cows were kept in the freestalls for the entire study period. In 2 herds, the

Table 1. Scoring system for classification of digital dermatitis lesions used in a Danish study evaluating the effect of 3 commercial hoof-care products used in footbaths (from Manske et al., 2002)

Score	Description
0	No lesions
1	Hyperemic area with erect pili
2	Moist, exudative, and hyperemic area, with intact epidermis
3	Exudative area, exposed corium, with no signs of healing
4	Exposed corium, but in the process of healing, dried-up lesion
5	Dark brown scab, completely or almost completely healed lesion

cows were kept on pasture for the last 6 and 10 d of the study period, respectively.

Digital dermatitis lesions were recorded on a 6-point scale (Table 1). For the analysis we classified scores 1, 2, 3, and 4 as active DD and score 5 as chronic, inactive DD. Only observations from the hind legs were used because the number of DD lesions on the fore legs was very low. In each herd, the effect of the treatment (hoof-care product or control) was evaluated on the cure of infected cows. The percentage of cows with active infections that were cured during the study period was calculated as $[N_{\text{cows}}(\text{active DD at start and not active DD at the end})] \times 100 / [N_{\text{cows}}(\text{active DD at start})]$, where N_{cows} is the number of cows.

The effect of the treatment (hoof-care product or control) was evaluated on the prevention of new infections. The percentage of cows with new infections was calculated as $[N_{\text{cows}}(\text{not active DD at start and active DD at the end})] \times 100 / N_{\text{cows}}(\text{not active or inactive DD at start})$.

These percentages were termed “percentage cured” and “percentage new infections” respectively, and were calculated for each side (treatment and control) and each herd separately. Initially, an analysis was performed to test for possible differences in DD status at the start between the treatment and control sides using a Wilcoxon signed rank test (Dawson and Trapp, 2004) and the UNIVARIATE procedure of SAS (version 9.1, SAS Institute Inc., Cary, NC). Hereafter, 2 analyses were performed because the optimal analysis was not possible. The optimal analysis was using a GLM model with herd and cows as random effects testing the difference between treatment and control on cured and new infections, respectively. This analysis would evaluate the treatment effect within cow (paired observations). Yet, convergence could not be obtained. Instead, the first analysis was performed using as many observations as possible without taking into account paired observations. The second analysis utilized the paired observations, albeit with a limited number of observations. In the first analysis the differences were tested in percentage cured and percentage new infections, respectively. Differences between the treatment and control side of each product were tested using a Wilcoxon signed rank test (Dawson and Trapp, 2004). This evalu-

ation was done using the UNIVARIATE procedure of SAS (SAS Institute Inc.). In the second analysis, McNemar’s test was used to test for a possible difference in cured legs and in legs with new infections between the treatment and control sides. This analysis used paired observations and was performed within cows for comparison of treatment versus control. Still, the number of cows for this analysis was limited because the DD status on the 2 legs at the start should be the same. For the analysis of cured legs, both legs at the start should have had active DD and for the analysis of new infections both legs should not have active DD at start. The FREQ procedure in SAS was used; a 5% significance level was used for all analyses.

Before the first hoof trimming, 50 randomly selected cows were scored in each herd for hygiene of the hind legs using the scoring system described by Schreiner and Ruegg (2002). This was done to take into account possible differences regarding the overall hygiene level of the legs in the herds. Possible differences between median hygiene scores in the herds were evaluated using a sign test (Dawson and Trapp, 2004).

RESULTS

The mean prevalence of active DD lesions on the hind legs at the start of the study was 21.8 and 22.7% for treatment and control sides, respectively. The herd prevalence of active DD lesions on the hind legs at the start of the study ranged from 4.4 to 47.8%. The overall prevalence across all herds of active DD lesions on fore legs was 2.6%. Table 2 presents the distribution of lesion scores for hind legs for treatment and control sides.

The mean number of cows that completed the study in each herd was 82.5. The cows not completing the study were culled or were unavailable for examination at the end of the study period (e.g., dry cows at pasture during the second examination).

Percentage cured and percentage new infections for each hoof-care product are presented in Table 3. There was no difference ($P = 0.73$) between the prevalence of active DD in treatment and control sides at the start of the study period. For all hoof-care products, there was no difference between treatment and control sides.

Table 2. Distribution of digital dermatitis lesion scores for hind legs for treatment and control sides in a Danish study evaluating the effect of 3 commercial hoof-care products used in footbaths

Score ¹	Treatment side (%)	Control side (%)
0	83.1	83.9
1	0.8	0.9
2	2.8	2.4
3	4.6	5.6
4	3.8	3.4
5	5.0	3.8

¹Scores: 0 = no lesion; 1–4 = active digital dermatitis; 5 = chronic, inactive digital dermatitis.

For percentage cured, $P = 0.13$, 0.88 , and 0.13 for Virocid, Kickstart 2, and Hoofcare DA, respectively. For percentage new infections, $P = 0.88$, 0.13 , and 0.63 for Virocid, Kickstart 2, and Hoofcare DA, respectively. McNemar's analysis revealed no difference in the probability of cured legs between treatment and control sides ($P = 0.14$) and no difference in probability of new infections between treatment and control sides ($P = 0.17$). In total, 535 cows had no DD on both legs at start of the study. Of these, 17 had new infections on both legs at the end of the study, whereas 38 had new infections only on the treatment side and 26 had new infections only on the control side. In total, 79 cows had active DD on both legs at the start of the study. Of these, both legs were cured for 16 cows, whereas 12 legs were cured for the control side only, and 5 legs were cured for the treatment side only.

There were no differences between median hygiene scores for legs in the 12 herds ($P = 0.39$). Median hygiene score for legs was 2.22 (interquartile range: 0.16). All herds had approximately the same level of hygiene regarding legs before the start of the study. Therefore, differences in the cleanliness of hind legs probably did not affect our results.

DISCUSSION

We found no effect of any of the tested hoof-care products on the cure or prevention of digital dermatitis even though they represented 3 major groups of active compounds. In a non-peer-reviewed study, Bergsten et al. (2007) evaluated the effect of copper sulfate against a negative control within cow in a herd with 112 cows. They found a large reduction in the odds of having DD using copper sulfate. The same study evaluated the effect of a combination of copper sulfate and peracetic acid; no effect was found. In a study in which 3 nonantibiotic hoof-care products were tested against erythromycin (study with a positive control; Laven and Hunt (2002) found no better effect of one product compared with others. Manske et al. (2002) found that an acidified ionized copper solution was more effective for curing DD in hind legs than water. However, no difference was found in fore legs and no difference was found in the prevention of DD. Silva et al. (2005) found a recovery of 73.3% among 30 cows treated with a footbath containing 1% sodium hypochlorite. Nevertheless, a control group was not included and therefore, it is impossible to know what the spontaneous recovery proportion would have been.

In the present study, the footbath was used twice daily on 2 d/wk. This practice was in accordance with the recommendations from the manufacturers of the hoof-care products. In other studies a much more intensive treatment regimen was used. Laven and Hunt (2002) treated the cows daily for 7 d. Manske et al. (2002) treated the cows for a total of 47 d, divided into 5 periods ranging from 3 to 16 d (median 10 d) distributed throughout the grazing period. The interval between treatment periods ranged from 4 to 14 d (median 5.5 d). Silva et al. (2005) used the footbath twice daily for 30 d. It is possible that we would have been able to

Table 3. Effect of 3 commercial hoof-care products on cure and prevention of active digital dermatitis tested in 4 Danish dairy herds¹

Item	Hoof-care product ²		
	Virocid	Kickstart 2	Hoofcare DA
Percentage cured			
Mean difference, treatment – control	–10.8 (–30.0; –2.2)	–6.1 (–33.3; 25.0)	16.5 (9.6; 20.0)
Percentage new infections			
Mean difference, treatment – control	–0.5 (–9.4; 3.9)	4.0 (1.4; 6.1)	–3.5 (–20.1; 9.0)
Mean prevalence of active digital dermatitis (%)			
At start, treatment side	30.5 (17.9; 47.2)	11.6 (3.5; 27.3)	25.7 (3.3; 51.1)
At start, control side	32.1 (26.2; 40.4)	12.0 (6.0; 28.6)	24.9 (5.6; 44.4)
At end, treatment side	26.7 (13.9; 37.1)	20.3 (5.1; 42.9)	15.8 (0.0; 36.7)
At end, control side	25.1 (16.7; 35.4)	17.0 (2.0; 37.7)	19.9 (1.1; 50.0)

¹Mean differences among all 4 herds within each hoof-care product in percentage cured and percentage new infections are shown, together with the mean prevalence of active digital dermatitis among all 4 herds. Values in parentheses show minimum and maximum percentages within each hoof-care product.

²Virocid and Kickstart 2: Cid Lines (Ieper, Belgium); Hoofcare DA: DeLaval (Drongen, Belgium).

demonstrate an effect on percentage cured or percentage new infections if we had used a more intensive treatment regimen.

We only treated one side of the cows. This means that the pathogen causing DD may remain “undisturbed” on the other side of the cow, which could have caused a greater infection pressure in the herd due to a higher number of pathogens in the environment. In turn, this might have caused a possible underestimation of the effect of the hoof-care products.

We used a controlled, clinical trial in which one side of the cow was treated and the other side was untreated (i.e., negative control). This is a very efficient way to evaluate the effect of one or more hoof-care products. The present study is the first study that compares the effect of more than one nonantibiotic hoof-care product with a negative control in a controlled, clinical trial in more than one herd. Additionally, the number of cows included was much larger than the relatively small number of cows included by Manske et al. (2002).

Fecal contamination is known to inactivate most hoof-care products (Gradle et al., 2002; Laven and Logue, 2006), but it is unclear to what extent cleaning of the hooves before passage through the footbath would have increased the effect of the hoof-care products. Further research is needed in this area.

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