Comparison of Two Footbath Solutions for Digital Dermatitis Control in Dairy Cattle: Two Point Two Percent (2.2%) Copper Sulfate with an Acidifier versus Five Percent (5%) Copper Sulfate

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ABSTRACT

The objective of this study was to compare a 2.2% copper sulfate footbath solution with 325.31 mL of an acidifier per 80 L water (treatment) to a 5% copper sulfate footbath solution (positive control) on the frequency and severity of digital dermatitis (DD) in lactating Holstein dairy cows (n = 59). The study was conducted at the University of Kentucky Coldstream Dairy from November 11, 2015, to January 20, 2016. Footbath solutions were delivered five times per week using a split footbath (Intra Care Foot Bath, Diamond Hoof Care LTD Alberta, Canada). The left side of the bath served as the positive control and the right side served as the treatment. DD lesions were scored biweekly and classified as active or non-active. The results of a chi-square test (calculated using the FREQUENCY procedure of SAS (SAS Institute, Inc., Cary, NC)) indicated no-significant difference in active lesion occurrences between the two footbath solutions (chi-square = 1.18, P = 0.56). The results of a McNemar's test indicated a significant decrease in active lesion occurrence from the beginning to end of the study (treatment: $P < 0.01$, positive control: $P < 0.01$). The acidifier may be a viable footbath solution alternative for dairy producers interested in reducing copper sulfate waste.

INTRODUCTION

Digital dermatitis (DD) is the leading cause of lameness in dairy cattle (Krull et al., 2014). Lesions are caused by the spirochete bacteria species, Treponema, often residing in manure slurry (Klitgaard et al., 2014). Digital dermatitis is extremely contagious,

Table 1. *Prevalence of all active lesions[1] from beginning to end[2] of the footbathing study for both the positive control[3] and treatment[4]*

Item	Positive Control[3]	Treatment[4]
No active lesion at week 1 and no active lesion at end	46	42
No active lesion at week 1 and active lesion at end	1	0
Active lesion at week 1 and no active lesion at end	11	13
Active lesion at week 1 and active lesion at end	1	4

[1]Lesions were scored using a M0 to M4 scale to analyze lesions (Döpfer et al., 1997).
[2]Beginning: November 11, 2015, Ending: January 20, 2016
[3]The positive control for this study was copper sulfate
[4]The treatment for this study was an acidifier product
[5]Numbers represent total hooves

and can lead to chronic lameness if not properly treated (Cha et al., 2010). Digital dermatitis lesions cost producers, on average, $132.96 per case (Cha et al., 2010). Lesions are most commonly found on the plantar portions of the hoof just above the coronary band, but can also be found in palmar and dorsal areas. Holzhauer et al. (2006) discovered that 21.2% (n = 22,454) of cows studied suffered from DD with herd-specific prevalence reaching as high as 83%.

Many farms use foot bathing as a method for DD prevention (approximately 38.9% of all operations and 80.8% of large operations (NAHMS, 2007)). A footbath usually consists of an aqueous solution with a chemical agent such as copper sulfate. Copper sulfate is the method of treatment for 63.6% of cows who are exposed to a footbath (NAHMS, 2007). Due to the adverse ecological consequences, expense, and difficulty of use, alternatives to copper sulfate are desired. Speijers et al. (2010) suggested copper sulfate alternatives were needed. Copper can accumulate in soils with the use of copper sulfate. This excess copper can build-up within the roots of plants, stunting their growth (Sheldon and Menzies, 2005). Copper is considered a hardy, environmental pollutant with long-term consequences, even with minimal use (Salam and El-Fadel, 2008). Similarly, products such as formalin are often used in prevention routines (Smith et al., 2014). Though formalin is effective, formalin is a known carcinogen and should be used with caution (Smith et al., 2014). Laven and Logue (2006) described the ideal method of prevention as being effective, even in the presence of manure slurry, without long-term harm to the environment, animals, or humans. Copper sulfate does not meet the aforementioned criteria. However, an acidifier may be used to decrease copper sulfate use while effectively preventing digital dermatitis in an environmentally conscious way. The objective of this study was to compare a 2.2% copper sulfate footbath solution with 325.31 mL of an acidifier per 80 L water (treatment) to a 5% copper sulfate footbath solution (positive control) on the frequency and severity of DD in lactating Holstein dairy cows.

MATERIALS AND METHODS

Footbath Treatments

This study was approved by the University of Kentucky Institutional Animal Care and Use Committee (IACUC protocol number: 2013-1143) and conducted between November 9, 2015, to January 20, 2016, at the University of Kentucky Coldstream Dairy Research Facility using lactating Holstein cows (n = 59). Cows were housed in free-stall style housing. Manure scrapings

Table 2. *Raw scores comparing prevalence of non-active digital dermatitis[1] lesions when comparing two different footbath solutions from beginning to end[2] of study.*

	Week 1 Lesion Frequencies [no. (% of digital dermatitis)]	Week 11 Lesion Frequencies [no. (% of digital dermatitis)]
Treatment[3]	51 (25.37)	46 (22.89)
Positive Control[4]	50 (24.88)	54 (26.87)

[1]Lesions were scored using a M0 to M4 scale to analyze lesions (Döpfer et al., 1997). For analysis, scores M1 and M2 were classified as active while scores M0, M3, and M4 were deemed non-active
[2] Beginning: November 11, 2015, Ending: January 20, 2016
[3]The positive control for this study was copper sulfate
[4]The treatment for this study was an acidifier product
[5] Numbers represent total hooves

occurred once daily. The herd was previously treated irregularly with a standard 5% copper sulfate footbath to control DD lesions. A split footbath (Intra Care Foot Bath -Diamond Hoof Care LTD) was used so that each cow served as her own control. Footbath solution delivery began on October 21st for both the control and treatment solutions. Hoof trimming occurred on November 2nd and scoring began on November 9th. Hoof trimming did not recur until after the conclusion of the study.

Cows were introduced to the footbath 3 weeks before the beginning of the study in an effort to familiarize the cows with the footbath design. During this introduction, the baths held a standard 5% copper sulfate solution. This footbath consisted of two plastic tubs measuring 32.5 cm wide and 233.0 cm long, with a steel coil fixed between the two tubs to prevent cross contamination and excess manure from entering the footbath. The left half of the footbath was designated as the positive control side and held 5% (3.97 kilograms) copper sulfate powder. The right half served as the treatment and held 2.2% (1.75 kilograms) of copper sulfate powder and 312 mL of acidifier. Both concentrates were mixed with 80 L water to form the solutions. Cows were exposed to the solutions five times per week immediately following milking. Footbaths were refreshed after the first three milkings, and then again for the two following milkings every week. Footbaths were refreshed upon the company recommendation of 150 cow passes to ensure the products did not lose their efficacy.

Lesion Scoring

No other hoof treatments or trimmings were conducted during the study. Lesion scoring was conducted biweekly by the same observer through the duration of the study. Before scoring, hooves were rinsed with water and a flashlight was used to aid in scoring. Lesions were scored using the Dop-

Table 3. *Raw scores comparing prevalence of active digital dermatitis[1] lesions when comparing two different footbath solutions from beginning to end[2] of the study.*

	Week 1 Lesion Frequencies [no. (% of digital dermatitis)]	Week 11 Lesion Frequencies [no. (% of digital dermatitis)]
Treatment[3]	8 (22.86)	13 (37.14)
Positive Control[4]	9 (25.71)	5 (14.29)

[1]Lesions were scored using a M0 to M4 scale to analyze lesions (Döpfer et al., 1997). For analysis, scores M1 and M2 were classified as active while scores M0, M3, and M4 were deemed non-active
[2]Beginning: November 11, 2015, Ending: January 20, 2016
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fer (1997) M0 to M4 scale. A score of M0 was assigned to cows who showed no signs of digital dermatitis. A score of M1 denoted a mild lesion. A score of M2 was reserved for critical lesions. These lesions were often bleeding, and occasionally elicited a painful response from the cow. Scores of M3 represented a healing lesion, often covered with a scab. A lesion score of M4 was used to describe chronic, often keratinized lesions (Döpfer et al., 1997). For analysis, scores M1 and M2 were classified as active while scores M0, M3, and M4 were deemed non-active.

Statistical Analysis

The FREQUENCY Procedure of SAS (SAS Institute, Inc., Cary, NC) was used to determine DD prevalence of active lesions at the beginning and end of the study. A McNemar's test and a chi-square analysis were performed using the FREQUENCY Procedure of SAS. The analysis was used to evaluate changes in digital dermatitis classification from study beginning to end. Only cows present for the duration of the study remained in the final statistical analysis. Cows may have been removed due to culling, dry off.

RESULTS

A McNemar's test indicated significant differences in the prevalence of active lesions from the beginning to end of the study, regardless of footbath solution (treatment: $P < 0.01$, positive control: $P < 0.01$; Table 1). Eighteen percent of positive control feet and 22% of treatment feet presented lesions at the beginning of the study and were cured of the lesions by the conclusion of the study. This represents the population of cows that ended the study with no active lesions. No significant difference in digital dermatitis active lesions between the two footbath solutions existed (chi-square = 1.18, $P = 0.56$). Additionally, no significant differences existed between either solution with the presence of non-active lesions ($P \geq 0.05$; Table 2). Thirty-seven percent of treatment cows experienced active lesions and 14% of positive control cows experienced active lesions at the conclusion of the study ($P \geq 0.05$; Table 3).

DISCUSSION

Although neither the treatment nor positive control was found to be effective without exception, both significantly decreased size and severity of DD lesions. Raw data suggests large differences in lesion occurrence. However, occurrences are not significantly different. These differences in raw values may be due to a small sample size. Active lesion prevalence (37%) was found to be lesser than similar studies in which 39% of cows had remaining lesions at the conclusion of the study (Smith et al., 2014). Speijers et al.(2010), found that both the group of cows receiving the control treatment and the group receiving the hypochlorite treatment experienced increases in active lesion prevalence, while only the copper sulfate treatment decreased lesions. The success of copper sulfate treatments are supported with this study as well. The treatment was determined to be effective in reducing lesion occurrence and preventing new occurrences. Therefore, it provides a viable opportunity to decrease copper sulfate consumption and lessen the ecological repercussions (Speijers et al. 2010).

Foot bathing is not meant to serve as a treatment for DD, but to prevent future outbreaks and reduce bacterial spread. Therefore, neither solution was expected to completely eradicate lesions. The perceived success of both solutions lends to the viability of the alternative. Copper sulfate has been found to be effective (Bergsten et al., 2006) and was confirmed with this study. Similarly, Formalin and antibiotics, such as Tetracycline, were found to be effective (Blowey, 2000). However, ecological implications (and legal implications in certain locations) associated with the use of ecologically deteriorative footbaths and carcinogenic risks associated with Formalin exist (Doane and Sarenbo, 2014). The acidifier works to modify solution pH without the use of phosphorous in order to prevent the build-up of excess phosphates in the soil.

Although more aggressive agents may be necessary for the treatment of DD incidences, an ecological and health conscious approach should be considered for blanket prevention. An acidifier is a possible solution to this need.

CONCLUSION

The acidifier is a viable option for decreasing copper sulfate usage for the prevention and treatment of digital dermatitis in dairy cattle. Although copper sulfate use is still necessary in conjunction with the acidifier, the quantity consumed is drastically lowered (a total decrease of 44.4 kilograms for this 10 week study). This may lead to ecological benefits for farmers while controlling digital dermatitis.

CONFLICT OF INTEREST STATEMENT

The authors have no financial obligations associated with this study. The experiment and paper were conducted and written without bias.

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