ALTERNATIVES TO COPPER SULFATE FOOTBATHS

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Walk-through footbaths are used on dairies to help control and prevent infectious claw lesions such as digital dermatitis, foot rot, interdigital dermatitis and heel erosion. In addition, footbaths may help harden claw horn, making it more resistant to horn lesions. One chemical commonly used in footbaths is copper sulfate. Copper sulfate has been used to control foot problems for many years. However, due to concerns regarding disposal of the copper sulfate solution from footbaths, many producers are seeking alternative solutions for controlling infectious lesions in dairy cattle. This paper will review some alternative products to use in footbaths, present strategies to make footbaths more effective and review some alternative methods to control infectious claw lesions.

Footbath Solutions

Footbaths are used primarily to control infectious claw lesions. If the primary lesions on a dairy are non-infectious, use of walk-through footbaths may not be warranted or frequency of use may be reduced. However, this decision can not be made unless accurate records are kept on the incidence and types of claw lesions.

Efficacy of footbaths in preventing infectious lesions is dependent upon a number of factors including footbath solution, frequency of changing solutions, footbath dimensions and footbath placement. Effectiveness of a footbath solution in preventing infectious lesions is dependent upon antimicrobial activity of the solution and the impact of soil load (organic matter) on antimicrobial activity of the solution. For instance, chlorine has a broad spectrum of activity against bacteria (Russell and Keener, 2007). However, chlorine has limited utility in footbath solutions as organic material such as manure reacts with the chlorine, resulting in loss of antimicrobial activity (Russell and Keener, 2007).

Copper Sulfate: Five to 10% copper sulfate solutions are commonly used in footbaths. Copper sulfate is an antibacterial agent that also has a hardening effect on claw horn (Kloosterman, 1997). The bacterostatic properties of copper sulfate are attributed to Cu++ reacting with protein thiol groups in target organisms (Epperson and Midla, 2007). The popularity of copper sulfate footbaths can be attributed to both its relatively low cost per footbath and widespread perception among dairy producers that it effectively controls infectious lesions. Research has shown that using copper sulfate footbaths decrease both incidence and severity of foot lesions (Laven and Hunt, 2002; Bergsten et al., 2006). However, some data suggest that copper sulfate is rapidly neutralized by organic matter (Greenough, 1997).

Concerns with using copper sulfate in footbaths include metal corrosion, disposal of the copper sulfate solution and increased claw horn permeability. Assuming that a dairy producer is using a 50-gallon footbath containing a 5% copper sulfate solution, 4X/wk, changed every 200 cow passes, 21.7 lb copper sulfate/cow per year is discarded.
Potential concerns with this level of copper excretion include reduced crop yields due to phyto-toxicity and exceeding EPA and state guidelines for copper loading of agricultural land (Rankin, 2004; Thomas, 2001).

The EPA Standard 503 for agricultural land cites a cumulative loading limit for copper of 1339 lb/acre and an annual application limit of 67 lbs/acre (EPA, 1999). In most cases, producers will not exceed these limits when applying manure containing discarded copper sulfate footbath solutions. However, some states have much lower limits for copper application. For instance in New York, the lifetime loading limit is 75 lbs/acre, while in Illinois, the lifetime copper application limit is 250 lbs/acre (Thomas, 2001). In these states, producers may exceed these limits by applying manure containing discarded copper sulfate footbath solutions to agricultural land. Dairy producers are strongly encouraged to check with regulatory officials to determine the lifetime copper application limit in their state and to insure that they are in compliance. Even if producers are in compliance with state and federal limits, they still need to insure that applying manure with discarded footbath solutions of copper sulfate does not result in reduced crop yields.

Another concern with using copper sulfate in footbaths is increased permeability of claw horn. Scottish researchers found that horn tubules of heel and sole horn placed in copper sulfate solution for 24 h absorbed the solution (Kempson et al., 1998). Intertubular horn was penetrated 3-4 mm in the heel and 2 mm in the sole after being soaked in copper sulfate for 24 h. After 4 days, copper sulfate had fully penetrated the thickness of the heel and sole horn slices. It is believed that the copper salts form compounds with the fatty acids of the horn which disrupt the intracellular matrix thereby compromising horn integrity (Kempson et al., 1998).

Similarly, soaking heel and sole horn slices in manure slurry resulted in manure slurry fully penetrating the horn (Kempson et al., 1998). In contrast, soaking horn slices in formalin had no effect on horn permeability. It should be noted that micro cracks did develop in the horn soaked in formalin and this may be due to shrinkage caused by dehydration of the horn as a result of being placed in the formalin solution.

**Formalin:** In addition to not affecting horn permeability, other advantages of using a 3 to 5% formalin footbath are that it kills bacteria, hardens claw horn, is inexpensive, soluble, bacteria do not develop resistance and formalin eventually breaks down into water and carbon dioxide (Shearer et al., 2005). It is a powerful disinfectant that reacts with the amino, carboxylic, and sulfhydryl groups in proteins, thus changing the conformation and functionality of the protein (Epperson and Midla, 2007). Research has shown that formalin footbaths reduce incidence and severity of foot lesions (Arkins et al., 1986; Laven and Hunt, 2002) and formalin may retain its antibacterial activity for up to 330 cow passes (Holzhauer et al., 2004).

However, many dairy producers are hesitant to use formalin in footbaths as it is a suspected carcinogen, it must be used in a well ventilated area and the person mixing the footbath solution must wear eye protection (Shearer et al., 2005). In addition, formalin may not be effective below 50°F and may slow healing of open claw lesions when treated
cows are required to walk-through footbaths (Shearer et al., 2005). Support from these concerns is based upon information and clinical experience demonstrating chemical burns in cows caused by the use of formalin solutions in excess of 5% (Raven, 1989). This can be especially troublesome if concentrated formalin footbath solutions accidentally come in contact with the cow’s udder and teats.

**Zinc Sulfate:** Anecdotal information suggests some success in controlling infectious claw lesions with the use of footbaths containing 5 to 20% zinc sulfate solutions. Zinc sulfate solutions do have antibacterial properties and may also act as a hardening agent. While zinc sulfate is relatively inexpensive to use in footbaths, it has not been widely used due to difficulty in dissolving most sources of zinc sulfate in water. Furthermore, controlled research on zinc sulfate footbaths for control of infectious foot skin lesions in cattle has not been conducted.

Poor solubility of zinc sulfate has prompted several companies to launch soluble zinc products for footbaths (Cook, 2007). The most notable of these products is a liquid zinc chloride product called Hoof Zink®. Field reports indicate Hoof Zink appears to be effective in preventing infectious claw lesions (Cook, 2007).

One advantage of using zinc based chemicals in footbaths is that zinc is commonly included in corn fertilization programs. Depending upon zinc content of soil, soil type and application method, up to 10 lb of zinc will be applied per acre (Shapiro et al., 2003). However, even dairy producers including zinc in corn fertilization programs, should be cautioned that if they are using a 50-gallon footbath containing 10% zinc sulfate solution, 4X/wk, changed every 200 cows, 17.6 lb zinc/cow per year will be dumped into manure and ultimately onto crop fields. According to EPA Standard 503, the cumulative loading limit for zinc is 2499 lbs/acre and an annual application limit of 125 lbs/acre (EPA, 1999).

**Antibiotics:** Occasionally, antibiotics have been used in footbaths. Some antibiotic footbath solutions that have been used include 0.1% oxytetracycline and 0.01% lincomycin (Shearer et al., 2005). Effectiveness of antibiotics in footbaths is suspect. Limited work suggests rapid neutralization of footbath solutions is the primary problem. Also, users are reminded that such application represents extra-label use of antibiotics. Furthermore, use of antibiotics in footbaths is costly and because of water quality issues (high mineral content, Ca and Mg carbonates) may require the use of distilled water for mixing (Shearer et al., 2005). Finally, limited evidence suggests that there is a potential for bacteria to develop resistance to the antibiotics.

**Commercial Products:** Table 1 includes a sampling of several products marketed for use in footbaths. This list is by no means complete nor is it an endorsement of any of these products. To our knowledge, there is no research on these products published in peer-reviewed journals, but rather the research has been reported in conference proceedings.

Field trials on two commercial dairy herds in the United States found that using a 5% Double Action® footbath solution for 3 to 12 months reduced incidence of digital
dermatitis by 57 to 80%, when compared with disease incidence at the start of the study (Seymour et al., 2002). In contrast, using a 5% Double Action footbath solution on a commercial dairy in Washington over a 12 week period did not reduce incidence of digital dermatitis (Janowicz et al., 2004). It should be noted that initial incidence of digital dermatitis was considerably lower in the Janowicz et al. (2004) study as compared with initial incidence rate of digital dermatitis in the Seymour et al. (2002) studies (5% vs. 15 and 23%).

Recently there have been several studies reported at conferences which involved the use of unique split-footbath design. Use of the split footbath allows researchers to literally do side by side comparisons of footbath solutions. The down side of using these footbaths is that the researcher is only able to compare two footbath solutions at the same time.

Research using the split-footbath system on two commercial Midwestern dairy herds found that a 2.5% copper sulfate footbath with PediCuRx TriFusion, 5d/wk for four consecutive weeks, resulted in a similar reduction in pain scores from digital dermatitis as that observed with a 5% copper sulfate solution (Gradle et al., 2006). British research using these split-footbaths on a commercial dairy herd found that using 2% Double Action footbath, 7X/wk for 6 months resulted in a similar incidence rate of digital dermatitis and heel erosion as compared with a 5% formalin footbath (Janowicz et al., 2006).

It should be noted that while research on the efficacy of the products listed in Table 1 is limited, using these products in place of copper sulfate will reduce copper disposal rates by 36% or more.

**Footbath Costs**
In addition to the concerns regarding the amount of metals discarded per cow per year, another concern with footbaths is cost. Using a footbath 4X/wk can cost $18 or more per cow per year. However, some dairy producers report spending more than $50/cow per year on footbath solutions.

**Improving Footbath Efficacy**
Proper use and management can improve efficacy of footbaths and reduce frequency of changing solutions. Footbaths should be located in frequently traveled areas such as the return alley from the milking parlor. Footbaths should be a minimum of 8 feet long, 3 feet wide (width may be reduced to 2 to 2.5 ft if the sidewalls on the footbath are 18 inches or higher) and 6 inches deep. Footbaths should be filled with a minimum of 4 to 6 inches of solution, ensuring that the skin of the interdigital space comes in contact with the footbath solution (Raven, 1989).

Producers should consider using a prebath in conjunction with a treatment bath. The prebath filled with either water or a soap and water mixture (1 quart dishwashing soap plus 24.75 gallons of water) should be located a minimum of 6 to 8 ft in front of the treatment bath encouraging cows to defecate prior to entering the treatment bath. In addition, separating the treatment and prebath by 4 to 6 ft results in only minimal
contamination of the treatment bath with the prebath solution (Cook, 2007). Prebath solutions should be changed as frequently, if not more frequently, than solutions in the treatment footbath.

It is recommended that footbath solutions be changed every 150 to 200 cows to maximize effectiveness of treatment solution. If group sizes are less than 150 to 200 cows, producers should alter times when footbath solutions are changed, so that cows in each group, periodically, have access to fresh solutions.

It should be noted that there is limited research on when is the optimal time to change footbath solutions. Currently, it is not known if the optimal interval for changing footbath solutions is dependent upon time, number of cow passes or both. In addition, the optimal interval for changing footbath solutions may vary from dairy to dairy depending upon cleanliness of cows, footbath size and footbath solution. Developing a quick, on farm test, may allow some producers to reduce the frequency of changing footbath solutions, while effectively controlling infectious lesions.

Feet should be as clean as possible to maximize the amount of skin and horn that come in contact with the treatment solution. If a manure cast covers the foot on a number of cows in the herd, producers may want to consider adding 2 quarts of laundry or dishwashing detergent per 50 gallons of prebath solution to facilitate removal of the manure cast. If a prebath is not used, producers may want to consider using the soap mixture in the treatment footbath 3X/wk followed by the treatment solution 3X/wk.

After cows have passed through the footbath, they should have access to a clean area for 1 to 2 hours to maximize effectiveness of the treatment solution. Also, feet should be routinely examined/trimmed (2 to 3X/year) by a trained hoof trimmer to ensure that horn overgrowth does not prevent the footbath solution from coming in contact with the interdigital skin.

Frequency of footbath use is dependent upon cleanliness of cows. Recently, Nigel Cook from the University of Wisconsin proposed using cow hygiene scores to determine frequency of footbath use (Cook, 2007). Cows are scored on a scale of 1 to 4: Score 1 = clean, little or no manure contamination of the lower limb; Score 2 = slightly dirty where the lower limb is lightly splashed with manure; Score 3 = moderately dirty, where there are distinct plaques of manure on the foot progressing up the limb; and Score 4 = very dirty, confluent plaques of caked on manure on the foot and higher up the lower limb. If greater than 75% of the cows score a 3 or 4, footbaths should be used 7X/wk, 51-75% score a 3 or 4, footbaths should be used 5X/wk; 25 – 50% score a 3 or 4, footbaths should be used 2X/wk and if less than 25% of the herd scores a 3 or 4, footbaths should be used as required to control infectious lesions.

Reducing the number of times footbaths are used each week can substantially reduce the cost of footbaths per cow as well as the amount of footbath solution that needs to be discarded. For a dairy producer using a 50-gallon footbath, containing 5% copper sulfate and changed every 200 cow passes, reducing footbath usage from 7X/wk to 2X/wk...
reduces the amount of disposed copper from almost 11 lb/cow per year to approximately 3 lb/cow per year. In addition, an overall contribution of footbath water to the lagoon can be realized by reducing footbath use, therefore reducing costs associated with liquid manure application.

**Individually Spraying Feet**

Another means to control infectious lesions, such as digital dermatitis, is spraying cows’ feet with medicated mixtures containing oxytetracycline (one 102.4 g packet of Terramycin® 343 per 1 gallon of distilled water), or lincomycin (one 16 gram packet of Lincomix®, Soluble Powder per two quarts distilled water). Approximately 10 to 20 cc of the medicated spray is applied per foot. Spray is applied on the heels, toes and any visible lesions. For the first week of treatment, all feet should be treated once daily for 5 to 7 consecutive days. Afterwards, continue daily treatment of all cows with visible lesions. **It should be noted that this is extra label use of these products and dairy producers should consult their veterinarian for a prescription, proper labeling and further instructions.**

The advantages of individually spraying cows to control infectious lesions is that copper content of animal waste is not increased and cost for purchasing treatment solutions is reduced. The disadvantages of individually spraying cows include increased labor requirement, inconsistent application or failure of treatment solutions to contact the interdigital space of all feet and the need to remove accumulated debris on feet to allow treatment solution to contact skin.

In addition, cows need to be sprayed in a location which allows the spray applicator to apply the solution to all feet. The location that appears to be most conducive to this exercise is in the milking parlor. The danger with applying antibiotic solutions in the milking parlor is contaminating milk with antibiotics. This may also be a concern if the medicated spray is applied outside the milking parlor, as there is always the risk of overspray landing on the cow’s teats and udder.

For this reason, some companies are marketing non-antibiotic sprays for aiding in control of infectious claw lesions. These products include Victory®, HoofPro+® and Oxy-Step®. Peer-reviewed research has found that response to Victory® was similar to oxytetracycline in that it reduced the number of visible lesions and reduced the number of cows with pain lesion scores > 0 (Hernandez et al., 1999). In a follow-up study, response to Victory® was better than oxytetracycline with regards to pain scores (Shearer and Hernandez, 2000). It should be noted that the formulation of Victory® has changed over the years and the authors are not certain if the product being marketed today is similar to product tested in the published research.

From peer-reviewed research, response to HoofPro+® has been mixed. In a Florida study, spraying with a HoofPro+® solution resulted in a response similar to spraying with water only (Hernandez et al., 1999), while a Wisconsin study found that spraying with a HoofPro+® solution was similar to spraying with an oxytetracycline solution in reducing lameness scores (Britt et al., 1996).
Stand-In Footbaths
Another alternative to walk-through footbaths is stand-in-footbaths. Stand-in footbaths are used to treat cows on an individual basis and are targeted primarily at cows chronically affected with infectious lesions (Raven, 1989). Cows stand in the footbath solution for 30 to 60 minutes in order to thoroughly disinfect the interdigital skin and heel bulb. The stand-in footbath appears to be most effective for cows in which claw shape or horn overgrowth limits the amount of footbath solution that comes in contact with the interdigital skin (Raven, 1989).

Use of stand-in footbaths allow the producer to intensify treatment of chronically infected cows, while reducing the frequency of use of walk-through footbaths for the remainder of the herd, resulting in reduced cost for footbath solutions and reduced concerns regarding disposal of spent footbath solutions. However, in order to effectively utilize a stand-in footbath, dairy producers must first have accurate records on claw lesions to identify cows chronically afflicted with infectious lesions and a relatively easy and efficient method of separating the chronically infected cows from herd mates and moving these cows to the stand-in footbath.

Summary
Dairy producers need to keep records on incidence and types of claw lesions to determine if use of walk-through footbaths for the entire herd is warranted. If incidence of infectious lesions such as interdigital dermatitis, digital dermatitis, foot rot and heel erosion are low (less than 5% total incidence of these lesions), producers should consider individual spraying or stand-in footbaths to treat afflicted cows, reducing cost of footbath solutions and reducing concerns regarding disposal of spent footbath solutions. In addition, producers should strive to maintain a strict bio-security program, especially when receiving cattle onto the dairy, to reduce the overall exposure of the herd to infectious pathogens.

While there are several alternatives to using footbaths containing copper sulfate solutions, there are concerns with each of these products, including effects on human health, lack of research/field experience and cost.

Producers can reduce the frequency of footbath use by reducing manure contamination of the footbath solution, ensuring that feet are clean to better facilitate contact of the treatment solution with interdigital skin, making sure that footbath solutions are changed when solutions are no longer efficacious (typically every 150 to 200), and ensuring that feet are properly trimmed to ensure maximum contact of the interdigital skin with the treatment solution.

Individually spraying cows and stand-in footbaths are alternatives to frequent use of walk-through footbaths and can reduce copper content of manure. However, topical spray does not reach interdigital lesions and labor requirements for these programs are higher.
Finally, more research needs to be conducted to determine efficacy of commercially available footbath products. In addition, a quick test needs to be developed to allow the producer to determine when the footbath solution is no longer effective in controlling infectious lesions. This will result in more effective control of infectious lesions while possibly reducing required frequency of changing footbath solutions.

References


Table 1. Some common commercial footbath products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Instructions</th>
<th>Potential Reduction in Cu/Zn Disposal&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy Foot®, low pH copper solution (SSI Corporation)</td>
<td>Cu 0.52% Zn 0.19%</td>
<td>0.5 gal per 50 gal H₂O + 5-7 lb CuSO₄ or ZnSO₄&lt;br&gt;Use daily for 5 d&lt;br&gt;Change every 150 cows</td>
<td>66.0% reduction in Cu disposal</td>
<td>Not available on footbath application</td>
</tr>
<tr>
<td>Rotational Zinc®, (SSI Corporation)</td>
<td>Zn 1.56%</td>
<td>0.5 gal per 49.5 gal H₂O + 5-7 lb ZnSO₄&lt;br&gt;Change every 150 cows&lt;br&gt;Use in rotation with other products</td>
<td>74.8% reduction in Zn disposal</td>
<td>Not available on footbath application</td>
</tr>
<tr>
<td>HoofPro+®, acidified ionized copper solution (SSI Corporation)</td>
<td>Cu 0.79%</td>
<td>0.5 gal with 49.5 gal H₂O + 5-7 lb CuSO₄&lt;br&gt;Change every 150 cows&lt;br&gt;Use 4 to 6 milkings/wk</td>
<td>65.5% reduction in Cu disposal</td>
<td>Not available on footbath application</td>
</tr>
<tr>
<td>Double Action®, (WestAgro, Inc.)</td>
<td>Quaternary ammonium compound</td>
<td>1 gal with 49 gal H₂O&lt;br&gt;Change every 200 cows&lt;br&gt;Lesion prevalence:&lt;br&gt;High – 2X/d for 7 d&lt;br&gt;Medium – 2X/d for 5 d&lt;br&gt;Low – 2X/d for 3 d&lt;br&gt;Most Commonly Used Only 1X/d</td>
<td>100% reduction in Cu and Zn disposal</td>
<td>Yes, but not peer-reviewed published</td>
</tr>
<tr>
<td>Hoof Zink (GARCO)</td>
<td>Zn 28%</td>
<td>1.32 gal with 50 gal H₂O</td>
<td>23% reduction in Zn disposal</td>
<td>Yes, but not peer-reviewed published</td>
</tr>
<tr>
<td>PediCuRx Trifusion (WestfaliaSurge)</td>
<td>~9% Cu-quaternary ammonium-peroxide complex</td>
<td>0.5 gal with 49.5 gal H₂O + 12 lb CuSO₄ or ZnSO₄&lt;br&gt;Change every 150-250 cows, depending on soil load</td>
<td>36 and 43% reduction in Cu and Zn disposal</td>
<td>Yes, but not peer-reviewed published</td>
</tr>
<tr>
<td>PediCuRx Complete (WestfaliaSurge)</td>
<td>~18% Cu-quaternary ammonium-peroxide complex</td>
<td>1 gal with 49 gal H₂O&lt;br&gt;Change every 150-250 cows, depending on soil load&lt;br&gt;Undiluted product can also be applied topically</td>
<td>71% reduction in Zn or Cu disposal</td>
<td>Yes, but not peer-reviewed published</td>
</tr>
<tr>
<td>PediCuRx Prevent A (WestfaliaSurge)</td>
<td>Quaternary ammonium compound</td>
<td>1 gal with 49 gal H₂O&lt;br&gt;Use in rotation with Prevent C and Z, change every 150-250 cows, depending on soil load</td>
<td>100% reduction in Zn or Cu disposal</td>
<td>Not available on footbath application</td>
</tr>
<tr>
<td>PediCuRx Prevent C (WestfaliaSurge)</td>
<td>Cu ~20%</td>
<td>1 gal with 49 gal H₂O&lt;br&gt;Use in rotation with Prevent A and Z, change every 150-250 cows, depending on soil load</td>
<td>63% reduction in Cu disposal</td>
<td>Not available on footbath application</td>
</tr>
<tr>
<td>PediCuRx Prevent Z (WestfaliaSurge)</td>
<td>Zn ~20%</td>
<td>1 gal with 49 gal H₂O&lt;br&gt;Use in rotation with Prevent A and Z, change every 150-250 cows, depending on soil load</td>
<td>72% reduction in Zn disposal</td>
<td>Not available on footbath application</td>
</tr>
</tbody>
</table>

<sup>a</sup> This list is not a complete listing of footbath products marketed in the United States nor is it intended to be an endorsement of any product listed in the table.

<sup>b</sup> Assumes an 8 ft. x 3 ft. footbath filled with 5 inches of solution, changed every 150 cow passes; compared to a 5% copper sulfate or a 5% zinc sulfate footbath solution.