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Short communication: Efficacy of copper sulfate hoof baths against digital dermatitis—Where is the evidence?

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ABSTRACT

Digital dermatitis is a major problem in modern dairy production because of decreased animal welfare and financial losses. Individual cow treatments are often seen as too time consuming by farmers, and walk-through hoof baths have therefore been used extensively to control digital dermatitis. For decades, copper sulfate hoof baths have been used to treat and prevent digital dermatitis. Copper sulfate has been referred to as the industry gold standard when it comes to hoof-bath chemicals. In several scientific studies testing the efficacy of other hoof-care products, copper sulfate has been used as a positive control, thereby indicating that copper sulfate has a known positive effect. However, this may not be the case. A dilemma may exist between (1) copper sulfate generally being perceived as being effective against digital dermatitis and (2) a possible lack of well-documented scientific evidence of this effect. The objective of this study was to evaluate the existing scientific literature to determine whether the efficacy of copper sulfate used in hoof baths against digital dermatitis has in fact been demonstrated scientifically. A systematic literature search identified 7 peer-reviewed journal articles describing the efficacy of copper sulfate in hoof baths as treatment or prevention of bovine digital dermatitis. Only 2 of the 7 studies compared copper sulfate to a negative control; most studies were relatively small, and often no clear positive effect of copper sulfate was demonstrated. In conclusion, the frequent claim that copper sulfate is widely reported to be effective is supported by little scientific evidence. Well-designed clinical trials evaluating the effect of copper sulfate against digital dermatitis compared with a negative control are needed. Until such studies have been made, the efficacy of copper sulfate in hoof baths against digital dermatitis remains largely unproven.

Key words: dairy cow, hoof bath, copper sulfate, digital dermatitis, evidence-based veterinary medicine

Short Communication

Digital dermatitis (**DD**) is a major problem in modern dairy production. Digital dermatitis is prevalent in many countries throughout the world (Rodriguez-Lainz et al., 1998; Holzhauer et al., 2006; Cramer at al., 2008; Thomsen et al., 2012) and causes financial losses due to, e.g., decreased milk production, excessive culling and extra work load, and compromised animal welfare due to discomfort and pain (Losinger, 2006; Bruijnis et al., 2010; Bruijnis et al., 2012). A case of DD has been estimated to have an average cost of $133 (Cha et al., 2010) and cow-level prevalences of DD are often reported to be 20 to 25% (Holzhauer et al., 2006; Cramer at al., 2008; Thomsen et al., 2012). This means that DD has a major negative effect on the farmer's economy.

The precise etiology of DD is still not fully understood. However, bacteria of the genus *Treponema* are considered to play a vital role—possibly in combination with other bacteria (e.g., *Dichelobacter nodosus*) and predisposing environmental factors (e.g., maceration of the skin; Rasmussen et al., 2012). Disinfectants and antibiotics are therefore frequently used to treat DD, copper sulfate ($CuSO_4$) being one of these disinfectants (Laven and Logue, 2006). The antibacterial properties of copper have been known for a very long time, the first reports of using copper against several diseases being more than 3,000 yr old (Konieczny and Rdzawski, 2012). Hartshorn et al. (2013) demonstrated an in vitro effect of copper sulfate against a *Treponema phagedenis*-like isolate. They also found that the effectiveness of copper sulfate was severely hampered when manure was present. However, no in vivo testing was done to evaluate the effect of copper sulfate against DD in live cows.

Individual cow treatments are often seen as too time consuming by farmers (Leach et al., 2010; Relun et al., 2013a), and walk-through hoof baths have therefore been used extensively to control DD. Several different hoof-bath chemicals have been used in such hoof baths. For decades, copper sulfate has been one of the most popular compounds used in hoof baths (Laven and Logue, 2006; Cook et al., 2012; Relun et al., 2013a), and

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it has been stated that copper sulfate is widely reported to be effective (e.g., Logue et al., 2012). Based on its frequent use, copper sulfate has been referred to as the industry gold standard when it comes to hoof-bath chemicals (Teixeira et al., 2010; Smith et al., 2014). In several scientific studies testing the efficacy of other hoof-care products, copper sulfate has been used as a positive control, thereby indicating that copper sulfate has a known positive effect (Teixeira et al., 2010; Logue et al., 2012; Smith et al., 2014). However, this may not be the case. Several authors have stated that in general there is too much anecdotal evidence and a lack of controlled clinical trials when it comes to the treatment and prevention of lameness in general and the efficacy of hoof-care products used in hoof baths in particular (Hirst et al., 2002; Laven and Logue, 2006; Thomsen et al., 2008; Potterton et al., 2012).

The dilemma that may exist between (1) copper sulfate generally being perceived as being effective against DD and (2) a possible lack of scientific evidence of this effect will be evaluated in this paper. The objective was to evaluate the existing scientific literature to determine whether the efficacy of copper sulfate used in hoof baths against DD has in fact been demonstrated and described in well-documented, peer-reviewed scientific journal articles.

A systematic literature search was conducted in September 2014 to identify relevant peer-reviewed scientific journal articles describing the efficacy of copper sulfate in hoof baths as treatment or prevention of DD. To maximize the chance of finding all relevant literature, the literature search was performed using the databases Web of Science, CAB Abstracts, and Scopus, based on the recommendations from Grindlay et al. (2012). The searches were based on the key words (hoof bath* or hoofbath* or foot bath* or footbath*) and (copper sulfate or coppersulfate or copper sulphate or coppersulphate or CuSO*). The search was not restricted to any species (e.g., cow) or disease (digital dermatitis) in order not to exclude any potentially relevant papers. The key words were searched in the title, abstract, or key words of articles. Peer-reviewed journal articles were included in the list of relevant literature irrespective of the year of publication. Only articles in English were considered. In addition to the systematic literature search, references in the identified articles were also scrutinized to find relevant literature, and all articles citing the identified articles were checked for relevance. All papers found during the literature search were scrutinized to check the relevance for the objective of this study, and papers not describing evaluations of the efficacy of copper sulfate in hoof baths against bovine DD were not considered further.

The literature search using Web of Science resulted in 29 papers (of which 25 were peer-reviewed articles) with information about hoof baths and copper sulfate, the search using CAB Abstracts resulted in 75 papers (25 peer-reviewed articles), and the search using Scopus resulted in 12 papers (8 peer-reviewed articles). Manual scrutiny of all identified papers showed that only 7 of these papers were peer-reviewed journal articles describing some kind of evaluation of the efficacy of copper sulfate in hoof baths against bovine DD. Other papers were either non-peer-reviewed articles, conference papers, or peer-reviewed scientific articles dealing with, e.g., residues of hoof-care products in milk, effects of copper sulfate on plant growth, evaluation of other hoof-care products than copper sulfate, or copper-based foot baths for treatment of ovine footrot.

Information about the 7 relevant peer-reviewed articles is summarized in Table 1. Laven and Hunt (2002) evaluated the efficacy of 4 hoof-care products. Four groups of cows in an experimental herd were treated with erythromycin, formalin, copper sulfate, or peracetic acid. All 4 treatments resulted in a decreased lesion score with time. Copper sulfate was as good as the other treatments but was not compared with a negative control. Speijers et al. (2010) compared 37 cows hoof bathed with copper sulfate with 39 control cows and found more cows with no DD lesions, less cows with active DD lesions, and more cows with chronic lesions in the treatment group. They found no effect of copper sulfate on the prevention of DD. Severe cases of DD were treated topically with antibiotics, and the possible effect of this on the prevalence of DD in the treatment and control group was not very well described in the article. Teixeira et al. (2010) used copper sulfate as a positive control when testing a commercial hoof-care product. They found no differences between the 2 treatments, and the prevalence of DD remained virtually unchanged throughout the study period irrespective of the product used. Logue et al. (2012) used copper sulfate as a positive control when testing a commercial hoof-care product. Both products were found to reduce the severity of DD lesion scores, and feet treated with copper sulfate were approximately 1.5 times more likely to improve compared with feet treated with the commercial product. However, this effect was only seen in 1 of 3 possible combinations of DD lesion scorings. Speijers et al. (2012) evaluated the effect of different hoof-bathing frequencies and found that more frequent use of copper sulfate hoof baths resulted in more cows without DD lesions. Also in this study severe cases of DD were treated topically with antibiotics. As part of a larger study on treatment strategies for infectious hoof disorders, Fjeldaas et al. (2014) evaluated the effect