



Research Article

The Effects of Footbath Management on Digital Dermatitis Distribution

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ABSTRACT

Digital dermatitis (DD) is a common infectious disease that causes economic losses and lameness. In order to keep DD under control, the usage of footbath is very important in intensive dairy farms. It was aimed to determine the relationship between footbath use and the number of active lesions related to DD. In total of 1527 cattle from 6 dairy farms were included in the study to assess and correlate the prevalence of DD and footbath practices. Information about the farm structure and management practice of footbaths was obtained through a questionnaire. It was inspected all feet of cattle with DD lesions during the milking time and scored the lesions using six M-stages. Thereafter, the chi square test was performed to investigate the relation between digital dermatitis prevalence and footbath applications. DD lesions in 500 feet (8.2%) of 338 (22.1%) was observed in dairy cows. Farms using dry manure as a bedding material showed a higher DD prevalence ($p<0.001$). Farms using formalin footbath had the lowest DD lesions, whereas copper sulfate (CuSO_4) practice had the highest prevalence ($p<0.001$). Periodically renewed footbaths showed a statistically lower DD prevalence in farms ($p<0.001$). We concluded that the convenient design and management of footbath might help to reduce the prevalence of digital dermatitis in dairy farms.

Keywords: Cattle, copper sulfate, digital dermatitis, footbath, formalin

Ayak Banyosu Kullanımının Digital Dermatitis Dağılımına Etkileri

ÖZET

Digital dermatitis (DD); ekonomik kayıplara ve topallığa neden olan yaygın bir enfeksiyöz hastalıktır. Digital dermatitis'le ya altında tutmak için, entansif süt çiftliklerinde, ayak banyolarının kullanımı çok önemlidir. Bu çalışmanın amacı; ayak banyosu kullanımı ile DD'ye bağlı aktif lezyon sayısı arasındaki ilişkiyi araştırmaktır. DD lea yak banyosu uygulamalarının yaygınlığını değerlendirmek ve ilişkilendirmek için, 6 süt çiftliğinden toplam 1527 sığır çalışmaya dahil edildi. Çiftlik yapısı ve ayak banyolarının yönetim pratiği hakkındaki bilgiler, anket yoluyla elde edildi. İneklerin ayaklarındaki DD lezyonları, sağım periyodu sırasında altı M-aşaması kullanılarak skorlandı. Daha sonra DD prevalansı lea yak banyosu uygulamaları arasındaki ilişkiyi araştırmak için ki kare testi yapıldı. Çiftliklerdeki 338 (%22.1) süt ineğinin 500 adet ayağında (%8,2) DD lezyonları gözlemlendi. Altlık olarak kuru gübre kullanan çiftlikler, daha yüksek bir DD prevalansı gösterdi ($p<0,001$). Ayak banyosunda formalin kullanan çiftlikler en düşük DD lezyonlarına sahipken, bakır sülfat (CuSO_4) kullanan çiftlikler en yüksek prevalansa sahipti ($p<0,001$). Ayak banyolarını periyodik olarak yenileyen çiftlikler, istatistiksel olarak daha düşük bir DD prevalansı gösterdi ($p<0,001$). Yapılan çalışmalar ve elde edilen sonuçlar doğrultusunda, uygun ayak banyosu tasarımı ve yönetiminin süt çiftliklerinde DD prevalansının azaltılmasına yardımcı olabileceği sonucuna varıldı.

Anahtar Kelimeler: Ayak banyosu, bakır sülfat, digital dermatitis, formalin, sığır

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Introduction

Digital dermatitis (DD) is a common infectious foot lesion in livestock animals typically in intensively managed dairy farming systems (Blowey, 2005; Cheli & Mortellaro, 1974; Cramer et al., 2008; Holzhauser et al., 2006; Read & Walker, 1998; Solano et al., 2016). DD is one of the most common causes of cattle lameness, which affects animal welfare and results with economic losses (Apley, 2015; Blowey & Sharp, 1988; Gomez et al., 2015). DD lesions can be painful and last for long terms (Bruijnis et al., 2012; Dopfer et al., 2012). Moreover, it can trigger disruptions in foot conformation that promote other infectious foot lesions (Gomez et al., 2015). In addition, DD has significant negative financial consequences associated with reduced milk production, reduced fertility rate, increased risk of culling, and increased cost of care (Akin & Akin, 2018; Bruijnis et al., 2010; Cha et al., 2010; Ettema et al., 2010; Holzhauser et al., 2008) due to its high incidence. Digital dermatitis is a multifactorial and a multi bacterial disease. *Treponema spp.* is frequently isolated from DD lesions (Döpfer et al., 2012; Gomez et al., 2015; Krull et al., 2016). This anaerobic spirochete bacteria can be identified in lesions (Blowey et al., 1994), indicating that they are invasive. Infected hoof trimming equipment and contact with manure are potential routes of transmission (Evans et al., 2012; Gillespie et al., 2020). Therefore, DD prevention techniques primarily involve the good hygiene practices and dry environment. To prevent the spreading of DD, host susceptibility (Scholey et al., 2010), inadequate hygiene and wet environments (Rodríguez-Lainz et al., 1996) should be eliminated and optimized.

Several control strategies have been recommended, including maintaining a clean, dry environment, individual topical treatment of affected cows, and herd-level strategies, including footbath usage (Dopfer et al., 2012; Laven & Logue, 2006; Nuss, 2006). Early intervention and effective topical treatments of active DD lesions increase cure rates and minimize spreading of the infection. In addition, an efficient footbath program can prevent active lesions from emerging (Dopfer et al., 2012). Footbaths are a common preventive method due to labor force needed to manage large numbers of sick cows, with strong evidence from intervention trials

supporting the effectiveness of footbathing in reducing the incidence of DD (Fjeldaas et al., 2014; Laven & Logue, 2006; Relun et al., 2012; Speijers et al., 2010). The most common substances in footbath practice are CuSO_4 and formalin. Unfortunately, CuSO_4 has adverse environmental effects (Flemming & Trevors, 1989; Hoff et al., 1998) and formalin is carcinogenic (Doane & Sarenbo, 2014). These impacts show the need for more experimental research on new chemicals or discovering the most effective use of the existing products. It is important to determine how often footbaths should be performed based on the hygiene score (Reneau et al., 2005). In order to increase the effectiveness of footbaths, cleaning animal's feet before entering the bath solution is important. The passage of animals in footbaths must be comfortable and the possibility of slipping should be eliminated. Mismanagement of one or more of these key points may decrease efficacy regardless of which footbath is used. Nevertheless, there is a broad variety in on-farm practices related to footbath protocols (Cook et al., 2012; Relun et al., 2013; Solano et al., 2015).

It was aimed to determine the relationship between footbath use and the number of active lesions related to DD. The protocol based on current scientific literature including footbath chemicals and management practice.

Materials and Methods

Farm and Cow Selection

A total of 6 freestall dairy farms in Aydin province in Turkey were contacted by a phone call to be enrolled as part of a longitudinal study. We selected the farms that met the requirements of the study. The requirements of the farms were; to have a freestall housing with no access to pasture, the herd size should be more than 50 lactation cows, cows had to milk in a milking parlor and farms had to have a DD prevalence (regardless of six M-stage) of $\geq 10\%$. Six farms met all criteria and agreed to participate in the study from July 2016 to July 2017. The Turkish Scientific Council of Turkey (2209/A, Application Number- 1919B011602116) approved all of the methods.

Study Design

A longitudinal observational study was conducted on

Table 1. Detailed table about footbath application practice from six dairy farms in Aydin, Turkey

Farm	Bedding type	Footbath dimensions (length × width × height) (cm)	Active Component	The number of footbath application days per week *
1	Dry Manure	150 × 150 × 10	CuSO_4 , Formalin	7d
2	Dry Manure	100 × 300 × 15	CuSO_4	2d
3	Dry Manure	90 × 300 × 20	CuSO_4	3d
4	Rubber Mattress	100 × 200 × 10	Formalin	5d
5	Straw Bedding	100 × 300 × 15	CuSO_4 , Formalin	2d
6	Dry Manure	-	-	-

*All farms except farm 6, applied footbath practices after milking.

Table 2. Distribution and prevalence of digital dermatitis (DD) lesions in farms

Farm	Number of cattle affected by digital dermatitis/ total number of cattle (%)	Affected Legs*				Total number of legs affected by digital dermatitis, n (%)
		RF	LF	LH	RH	
1	39 / 160 (24.38)	2	-	28	23	53 (33.97)
2	97 / 203 (47.78)	8	11	67	78	164 (42.27)
3	81 / 224 (36.16)	-	1	57	55	113 (34.88)
4	62 / 543 (11.42)	43	-	39	-	82 (33.06)
5	49 / 272 (18.01)	1	1	31	38	71 (36.22)
6	10 / 125 (8.00)	1	1	9	6	17 (3.40)
Total, n (%)	338 / 1527 (22.13)	55	14	231	200	500 (8.18)

* RF: Right front leg, LF: Left front leg, LH: Left hind leg, RH: Right hind leg

the selected farms. All lactating cows were assessed for DD lesions in the milking parlor. The 6 farms were visited on predetermined days to gathering information about prevalence of DD, farm structure, footbath and management practice (Table 1). We inspected the entire lactating herd in the milking parlor. Farmers were encouraged to continue their regular individual treatments for DD.

General Management

A questionnaire was conducted in each farm. The questions were either open-ended (e.g., "What is the active ingredient used as a footbath?") (Table 1) or closed-ended (e.g., "Do you use a footbath on the farm?"; response scale: yes or no). Specific information on the frequency of its use (how many times per week) and the renewing frequency of solutions also obtained from the questionnaire. In addition, the dimensions of footbaths measured (length, depth, and width) on each farm (Table 1).

Assessment of Digital Dermatitis Lesions

According to Döpfer et al. (1997), the DD lesions were scored by using the six M stages. The skin categorized as M5, if it was normal and without any DD-compatible lesions. Lesions were categorized as M1, if a small focal clinical lesion (< 2 cm in diameter) observed, with red-gray surface and small red foci dispersed (~ 1 mm in diameter), M2 if an ulcerative active lesion of around 2 cm in diameter observed, with extensively mottled a red-gray surface. M3 (healing stage) was determined if the lesion has a dry brown and scab-like tissue. This typically seen within a few days of topical treatment. Lesions were categorized as M4 (chronic stage) if a tan irregular hyperkeratotic surface was observed. M4.1 was chronic stage with a small active painful M1 focus. A professional observer completed all DD assessments throughout the presented study. Except M5, other M stages recorded as digital dermatitis.

Milking Parlor Inspection

Throughout the entire study, we visited each farm to obtain the correlation between footbath usage and its effects on the prevalence of digital dermatitis. During

milking, we washed cow's hind and front feet with hose water before the examination to get a clear image of the lesion if present.

Statistical Analyses

We entered all gathered data into Excel (Microsoft Corp., Redmond, WA) and performed all statistical analyses using IBM SPSS Statistic 22.0[®] (IBM, Armonk, NY). A *p*-value of <0.05 considered significant for all analyses. The relationship between footbath use and the number of active lesions related to DD examined using the "Chi-Square" test.

Results

Average herd size was 254.5 lactating cows (range, 125 to 543). Footbaths had a median length of 108 cm (range, 90 to 150), width of 250 cm (range, 150 to 300) and a mean depth of 14 cm (range, 10 to 20). Two farms used a combination of two active chemicals (CuSO₄ and Formalin). All farms had an individual DD treatment protocol in place. Farm number 3 and 4 renewed their footbath after milking, whereas farm number 1, 2 and 5 did not renew it regularly.

Digital Dermatitis Prevalence

A total of 6108 observations on 1527 lactating cows (6108 feet) in 6 farms were collected throughout the study period. As a result, Digital Dermatitis observed in 500 feet (8.2%) of 338 (22.1%) dairy cows in total. 5608 feet classified as healthy (no DD lesions) (91.8%) (Table 2).

Associations Between Digital Dermatitis and Footbath Managements

The existence of digital dermatitis cases was statistically significant between dry manure (farm no: 1, 2, 3, and 6) (farm no: 1, 2, 3, and 6) with rubber mattress bedding (farm no: 4) practices (*p*<0.001). There was also a statistically significant difference in the presence of digital dermatitis between straw (farm no: 5) with dry manure bedding (farm no: 1, 2, 3, and 6) practices (*p*<0.001). There were statistically significant differences between CuSO₄ (farm no: 4) and CuSO₄+formalin (farm no: 1 and 5) farms on the relationship between the use

Table 3. Digital dermatitis (DD) lesion distribution and their association with management factors

		Number of DD Lesions (n)		Farm Number	P-value
		Exist	Non-Exist		
Bedding material	Dry Manure	227	485	(1, 2, 3, 6) ^a	<0.001
	Straw Bedding	49	223	(5) ^b	
	Rubber Mattress	62	481	(4) ^b	
Active chemical	CuSO ₄	178	249	(2, 3) ^a	<0.001
	Formalin	62	481	(4) ^a	
	CuSO ₄ , Formalin	88	344	(1, 5) ^b	
	Not Used	10	115	(6) ^b	
Frequency of footbath application per week?	2	155	320	(2, 5) ^a	<0.001
	3	81	143	(3) ^a	
	5	62	481	(4) ^a	
	7	39	121	(1) ^b	
	Not Used	10	115	(6) ^a	

* Different superscript letters indicate statistical significance.

and types of active chemicals and the existence of digital dermatitis ($p < 0.001$). The existence of digital dermatitis lesions was statistically significant ($p < 0.001$) on farms with footbath use with CuSO₄+Formalin (farm no: 1 and 5) and no footbath used dairy farms (farm no: 6). There was a statistically significant difference in digital dermatitis existence between farms that used formalin as an active chemical on footbath (farm no: 4) and farms that did not use footbath practice (farm no: 6) ($p < 0.001$). According to the frequency of footbath use, digital dermatitis lesion cases were statistically higher ($p < 0.001$) in farms (farm numbers 2 and 3,4, 5) that did not renew or did not implement any footbath in their farm (farm no: 6).

Discussion

In this study, the prevalence of DD lesions in herds was associated with footbath management. As an interpretation, footbath practices among producers remain empirical as it relies on mouth-to-mouth advice from other farmers leading non-standardized managements (Relun et al., 2013).

It is widely known that inadequate hygiene is leading to digital dermatitis (Potterton et al., 2012). Dairy management practices such as floor scrapping, bedding material, and cow's diet may directly affect environmental hygiene and lead to contaminated footbaths. The defecation rates inside of the footbath were mentioned in previous studies (Fjeldaas et al., 2014). A previous study claimed that cows can defecate in the alleys between the milking parlor and footbath after adaptation of frequent renewal of footbaths (Ariza et al., 2019). The renewal rate of footbath can affect the defecation rate inside the footbath therefore decrease the contamination of footbath solution especially for the farms with a long interval (Ariza et al., 2019). Also, a large volume of footbaths and less frequency of renewal might

lead footbath solutions to a slurry include manure, urine, and dirt (Holzhauer et al., 2006). The close and frequent contact of the feet with slurry might alter the skin permeability, and increase the risk of infection (Palmer et al., 2013). Solano et al. (2017) investigated the influence of literature guidelines concerning footbath dimensions and protocols using a footbath protocol of 5% CuSO₄ for 4 consecutive milking (2 days), with a limitation of 200 total passing cows. They assumed that footbath dimensions and changing frequency might have an effect in the prevalence of DD lesions. In our present findings, average value of footbath dimensions was 108 cm × 250 cm × 14 cm, whereas just two of the farms renewed their footbaths regularly after milking. There were statistically significant differences between footbath used and not used dairy farms ($p < 0.001$). Interestingly, there was no statistically significant difference in between farms with footbaths in terms of frequency of footbath use (Table 3).

The presence of feces creates a suitable environment for DD factors (Sullivan et al., 2015). Similarly, in the present study, the prevalence of DD lesions was more common in farms using dry manure as a bedding material. The possible reason for this is that rain and constant urination are unable to avoid. If not managed properly, it should be assumed that the causative source could be the bedding material used, and it should assess that DD lesions may be more prominent. In the present study, there were statistically significant differences on cases of digital dermatitis lesions between dry manure bedding with straw or rubber mattress used dairy farms as a bedding material ($p < 0.001$). This result may be related with the use of dry manure which led an environment for DD lesions on dairy farms.

In the present findings, there were statistically significant differences on DD lesions cases with footbath practices and active chemical used in footbaths (Table 3, $p < 0.001$).

Despite the widespread use and proven effectiveness of footbaths (Laven & Logue, 2006), footbathing is an expensive practice primarily due to labor costs (Bruijnjs et al., 2013). On the other hand, the advantages of providing clear and accurate footbath procedures may lead to a decreased incidence of DD and, therefore, lower costs associated with hoof trimming, treatments, and a high benefit to welfare. However, in the present study, there was no footbath in Farm No: 6, and Digital Dermatitis lesions were detected in 8.0% of the population. As a limitation, the concentration of used footbath chemicals, renew rate of the farm number 1, 2 and 5, the chemical amount used in footbaths, hygiene of the walking alleys or claws were not taken into account in the present study due to limited visit days to the farms and the willingness of not intervene any protocol in farms. This may be related to the present study's finding such as there was no statistically significant relationship between the use of combined use of CuSO_4 +formalin and digital dermatitis prevalence (Table 3). It may be more beneficial not to use a footbath at all, than if it is not prepared properly.

Conclusion

The use of footbath is very important in terms of the prevalence of digital dermatitis. Mentioning these results in farms that exist or will be built in similar climatic geographic regions may help to decrease the prevalence of digital dermatitis. Furthermore, instead of inappropriate usage on fields, it might be best not to use footbath at all.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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