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Changes in teat-end hyperkeratosis after installation of an individual quarter pulsation milking system

A. E. Sterrett,* C. L. Wood,† K. J. McQuerry,† and J. M. Bewley*[1]
*Department of Animal and Food Sciences, and
†Department of Statistics, University of Kentucky, Lexington 40546

ABSTRACT

The objective of this study was to examine changes in teat-end hyperkeratosis (HK) in a herd transitioning from a standard pulsation milking system to an individual quarter pulsation milking system. The Milpro P4C (Milkline, Gariga di Podenzano, Italy) system stops milking individual quarters using an individual quarter pulsation milking system with 4 independent pulsation channels per cluster instead of 2. Teat-end HK was evaluated immediately after cluster removal using a scoring system where N signifies no ring; S signifies a smooth, raised ring; R signifies a rough ring; and VR signifies a very rough ring. Scorings were classified for 69 cows (48 Holstein, 12 crossbred, and 9 Jersey) on 5 dates relative to installation of the Milpro P4C system on April 28, 2011, as follows: April 7 (PRE1); April 21 (PRE2), May 12 (POST1), May 26 (POST2), and June 9 (POST3). Hyperkeratosis classifications were converted to numerical scores as follows: N = 1, S = 2, R = 3, and VR = 4. The MIXED procedure of SAS (SAS Institute Inc., Cary, NC) was used to evaluate fixed effects of age, breed, parity, teat position, and all interactions on teat-end HK score with variables repeated by scoring with cow within breed as subject. The effects of teat position and scoring × breed on teat-end HK score were significant. Holstein HK scores improved from PRE2 to POST3 (1.64 ± 0.09 and 1.42 ± 0.10, respectively), POST1 to POST3 (1.59 ± 0.10 and 1.41 ± 0.10, respectively), and POST2 to POST3 (1.53 ± 0.10 and 1.42 ± 0.10, respectively). Crossbred HK scores did not differ among scorings. Jersey HK scores worsened from POST1 to POST3 (1.32 ± 0.21 and 1.63 ± 0.22, respectively). For all cows included in the final analysis, right front and left front HK scores were higher than right rear and left rear HK scores (1.58 ± 0.09, 1.62 ± 0.09, 1.37 ± 0.09, and 1.36 ± 0.09, respectively). However, a significant decrease in teat-end HK scores for Holsteins did occur from PRE1 to PRE2 (1.75 ± 0.10 and 1.63 ± 0.10, respectively) and may represent biological variation in teat-end HK over time unrelated to installation of the individual quarter pulsation system. Individual quarter pulsation milking systems may prevent overmilking and reduce HK in Holstein cows. Further research is warranted to understand the breed differences observed in this study.
Key words: hyperkeratosis, teat end, individual quarter pulsation

INTRODUCTION

The teat end or orifice is an important first line of defense in protecting the udder from invasion of mastitis pathogens (Gleeson et al., 2004). The maintenance of healthy teat skin and teat ends is a key component of an effective mastitis prevention program (Mein et al., 2001). After repeated milkings, a callous ring around the teat orifice may develop, termed hyperkeratosis (**HK**; Neijenhuis et al., 2001b). Hyperkeratosis refers to a histological response to chronic stimulation and is marked by an increase in the thickness of the stratum corneum or the keratin layer of the teat end (Breen et al., 2009).

Overmilking occurs when the milk flow to the teat cistern is less than the flow out of the teat canal, and it can cause or exacerbate teat-end HK. Rasmussen (2004) explained that breeding for high milk yield has produced cows with a higher percentage of cisternal capacity within the udder, reducing udder emptying functionality. Mechanical forces exerted by vacuum and the moving liner during machine milking affect teat-end HK incidence (Neijenhuis et al., 2000, 2001b). Rasmussen (1999) proposed that the last 0.5 min of milking was the most sensitive period for developing HK because the teats were almost empty. Other factors not examined in this study that affect teat-end HK include teat-end shape (Neijenhuis et al., 2000; Gleeson et al., 2004), genetic predisposition (Gleeson et al., 2004), seasonal weather conditions (Mein et al., 2001), and long unit-on times (Zucali et al., 2008). Teats with unit-on times <4.30 min were 0.29 times less likely to develop HK scores of **R** (rough ring) or

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[1]Corresponding author: jbewley@uky.edu

VR (very rough ring) than teats with unit-on times >5.30 min ($P < 0.01$), citing more liner collapses as a possible cause of high HK scores. In the same study, teats starting with an HK classification of **N** (no ring) were 0.38 times less likely to be scored R and VR than teats starting with an HK classification of **S** (smooth, raised ring; $P < 0.01$). Conversely, teats that started with an HK classification of R or VR were 24.2 times more likely to end with a classification of R or VR than teats starting the experiment with a classification of S. The study results demonstrated the difficult recovery from severe HK (Zucali et al., 2008).

Dairy advisors associate more severe HK with increased clinical mastitis incidence (Neijenhuis et al., 2001a). In an 8-herd study, the odds of contracting *Streptococcus uberis* or *Escherichia coli* clinical mastitis increased significantly with increased HK (Breen et al., 2009). O'Shea (1987) proposed that changes to teat-end condition resulting from overmilking might increase the likelihood of bacterial penetration into the udder. Natzke et al. (1978) determined that more new infections occurred in cows when milking units were set at a fixed removal time of 12 min (40, 27, and 15 new infections for 3 experimental repetitions) compared with cows with milking units removed at the end of milk flow (19, 20, and 12 new infections for 3 experimental repetitions). Natzke et al. (1978) concluded that overmilking may have contributed to higher mastitis infection rates, likely due to teat-end condition, but the differences in infection rates between the 2 groups were not significant ($P > 0.05$). Rasmussen (1999, 2004) explained that the reverse pressure gradient created when the vacuum in the teat cistern is higher than that beneath the teat end may allow for bacterial invasion of the teat cistern, making overmilking a culprit for increased bacterial colonization at the teat end. Each 1-unit increase in teat-end HK score increased the chances of intramammary infection by 30% in a study conducted by de Pinho Manzi et al. (2012). Hyperkeratosis scores were positively correlated with bacterial counts of the environmental pathogens *Strep. uberis*, *E. coli*, and other coliforms ($r > 0.50$, $P < 0.01$), but not with *Staphylococcus aureus* (Paduch et al., 2012). Rough teat ends may provide a site for bacterial colonization because they may be more difficult to clean during premilking preparation (Zucali et al., 2008). However, Shearn and Hillerton (1996) failed to identify a significant relationship between SCC and degree of HK at the herd level.

Individual quarter pulsation milking systems may prevent overmilking and improve teat-end condition (Neijenhuis et al., 2000). Automated milking systems often incorporate individual quarter pulsation, but research on this feature in a conventional parlor is lacking. Automated milking systems have not been heavily adopted in the United States because of the availability of inexpensive labor relative to that in other countries (Jacobs and Siegford, 2012). The objective of this research was to examine changes in teat-end HK in a herd transitioning from a standard pulsation system to an individual quarter pulsation milking system.

MATERIALS AND METHODS

This study was conducted at the University of Kentucky Coldstream dairy from April to June 2011. Teat-end HK was evaluated by the first author immediately after cluster removal using the scoring system outlined by Mein et al. (2001), where N indicates no ring; S indicates a smooth, raised ring; R indicates a rough ring; and VR indicates a very rough ring. Scoring periods were classified relative to installation of the Milpro P4C (Milkline, Gariga di Podenzano, Italy) system (April 28, 2011) as follows: April 7 (**PRE1**), April 21 (**PRE2**), May 12 (**POST1**), May 26 (**POST2**), and June 9 (**POST3**).

Ambient weather conditions were recorded at 1-h intervals at the Lexington Bluegrass Airport (14.2 km from the study site). Temperature-humidity index (**THI**) was computed using the following formula (NOAA, 1976): THI = temperature (°F) − [0.55 − (0.55 × relative humidity/100)] × [temperature (°F) − 58.8].

Cows were milked twice daily before and after installation of the new system. Milking routine before and after installation included forestripping, predipping, drying teats with individual paper towels, unit attachment, automatic takeoff, and postdipping. No changes were made to the milking routine after installation. The herd was divided into 2 balanced groups based on parity, breed, and size for a separate research project throughout the entire study period. Each group was milked in 1 of 2 double-2 bypass parlors, located in the same building. High lines were used before and after installation. Vacuum pressure was adjusted to manufacturer recommendations after installation of the new system

Before installation, cows were milked using Surge Eclipse claws with 06 shells, 1st Choice triangular inflations, and Surge Omni cylinder detachers with optical sensors (GEA Farm Technologies Inc., Naperville, IL). The Milpro P4C (Milkline, Gariga di Podenzano, Italy) system, equipped with silicone liners, stops milking individual quarters based on flow rates, and has a unique individual quarter pulsation milking system with 4 pulsation channels instead of 2. Pulsation ratio and frequency are variable and driven by the milk flow in the Milpro P4C system. As the flow increases, the length of the milking phase (A + B, where A is the opening phase and B is the milking phase) increases, whereas