J. Dairy Sci. 88:3354–3362

Visual Detection of Technical Success and Effectiveness of Teat Cleaning in Two Automatic Milking Systems

M. Hovinen,[1] A.-M. Aisla,[2] and S. Pyörälä[1]
[1]Department of Clinical Veterinary Sciences, P.O. Box 57, and
[2]Department of Agricultural Engineering and Household Technology, P.O. Box 27,
00014 University of Helsinki, Finland

ABSTRACT

Technical success and effectiveness of teat cleaning and the management factors associated with them were evaluated in 9 automatic milking herds. In total, 616 teats cleaned with a cleaning cup and 716 teats cleaned with rotating brushes were included. Technical success and the effectiveness of teat cleaning, including the location and nature of the dirt, were evaluated visually. On average, 79.9% of teat cleanings with a cleaning cup, and 85.0% of those cleaned with brushes succeeded technically; that is, the teat was correctly positioned in the cleaning device throughout the whole cleaning process. The difference between use of teat cups and brushes was significant. However, because technical success of teat cleaning is strongly dependent on herd characteristics, these results should be interpreted with caution. Factors associated with the technical success of teat cleaning with a cleaning cup were herd, days in milk, behavior of the cow, teat color, and teat location. For rotating brushes, behavior of the cow, teat location, udder and teat structure, and days in milk were associated with technical success. Excessive udder hair and technical failure of the automatic milking machine also caused a few technically unsuccessful teat cleanings with a cleaning cup. Teats with technically successful teat cleanings were evaluated for the effectiveness of teat cleaning. From originally dirty teats, the cleaning cup had a significant advantage over the brushes in the percentage of teats that became clean or almost clean during the cleaning process (79.8 vs. 72.9%). Teat orifices were least effectively cleaned compared with the teat barrel and apex. Bedding material (peat, sawdust, or straw) on the teat was cleaned almost completely. Factors associated with the effectiveness of teat cleaning were teat cleanliness before cleaning, herd, teat cleaning method, and teat condition. The variation among herds indicates the likelihood that herd management factors can be adjusted to improve milking hygiene. There is also a need to improve the precision and effectiveness of the teat cleaning mechanisms of automatic milking systems.
(**Key words:** automatic milking, teat cleaning, effectiveness of teat cleaning, technical success of teat cleaning)

Abbreviation key: AMS = automatic milking system, **ETC** = effectiveness of teat cleaning, **TSTC** = technical success of teat cleaning.

INTRODUCTION

Proper milking hygiene is essential for the production of good quality raw milk and for the udder health of the cows (Pankey, 1989; Rasmussen et al., 1991; Bartlett et al., 1992). Raw milk may become contaminated by bacteria from teat surfaces, mastitic milk, or contact surfaces of milking equipment (Galton et al., 1982). Coliforms from manure or bedding, spore-forming bacteria from silage, and potentially zoonootic bacteria may place consumers at risk (Slaghuis, 1996; Sumner, 1996). Mastitis pathogens may enter the teat canal during milking in suboptimal milking conditions (Rasmussen et al., 1994), and there is evidence of an association between teat or udder contamination and appearance of mastitis (Galton et al., 1988; Schreiner and Ruegg, 2003). According to legislation in the European Union, the udder and teats of a cow must be clean before milking (Council Directive 89/362/EEC, 1989).

Automatic milking processes include teat cleaning with automated devices. No method has been developed for distinguishing between dirty and clean teats before cleaning, or for monitoring the effectiveness of the cleaning (Mottram, 1997). Not all of the current automatic milking systems (**AMS**) have sensors to detect whether the teat is in the cleaning device during cleaning and whether it is actually cleaned. The effective operation of the AMS is crucial, because in automatic milking, the result of teat cleaning no longer depends on the careful vigilance and decision making of the milker.

There is limited research on the effectiveness of teat cleaning (**ETC**) and the technical success of teat clean-

Received February 11, 2005.
Accepted June 2, 2005.
Corresponding author: Mari Hovinen; e-mail: mari.hovinen@helsinki.fi.

ing (**TSTC**) in AMS. The only published study of TSTC comes from Norway, in which approximately 10 to 20% of the teat cleanings per cow were unsuccessful (Hvaale et al., 2002). Some studies have been published on the ETC of automatic milking in experimental conditions (Schuiling, 1992; Melin et al., 2002; Ten Hag and Leslie, 2002; Knappstein et al., 2004) or in field conditions (Knappstein et al., 2004; Tangorra et al., 2004). Taken together, the results of these studies are inconclusive, possibly because of use of differing experimental methods.

The aim of this study was to evaluate both the technical success of teat cleaning and the effectiveness of teat cleaning in commercial herds using automatic milking systems and to examine possible reasons for failures. Another objective was to document potentially important herd management factors that may affect teat cleaning in such systems.

MATERIALS AND METHODS

Herds

Nine commercial dairy herds that had been milked automatically for a minimum of 6 mo, had only 1 automatic milking stall, and were willing to participate in the study were included. To clean the teats automatically, a teat-cleaning cup was used in 5 herds (Group A), and rotating brushes were used in 4 herds (Group B). All 9 herds were visited once from September to December 2003. Group A consisted of 161 cows with 616 milking teats, and Group B consisted of 184 cows with 716 milking teats.

Automatic Milking Systems

Teat cleaning system of Group A has a separate cleaning cup which uses warm water, variable air pressure, and vacuum to clean the teats. The system also foremilks the teats and dries them afterwards with warm air. The length of the cleaning process can be adjusted for each cow. Teats are located by lasers and a camera before cleaning.

The teat cleaning system of Group B uses wet rotating brushes to clean the teats from apex to base and back. After cleaning, the brushes are sprayed with warm water and disinfectant. The number of brushing sequences is adjustable for the herd. The teats are located by the machine based on earlier coordinates of the udder.

In this study, cows in Group A had normal teat washing regimens (12 s/teat) and cows in Group B had 2 brushing sequences (as recommended by the manufacturer). Teat cleaning devices were visually clean and undamaged at the time of evaluation.

Technical Success of Teat Cleaning

Technical success of teat cleaning was evaluated visually and recorded as successful, partly unsuccessful, or totally unsuccessful. Cleaning was successful if the teat was straight and completely in the cleaning device throughout the cleaning process (or throughout both cleaning sequences for Group B). Cleaning was partially unsuccessful if the teat was folded against the udder base or otherwise only partially in the cleaning device, or not in the cleaning device for the whole time of the cleaning. Cleaning was totally unsuccessful if the teat was not in the cleaning device or if the cleaning process never took place for that particular teat. Teats that were cleaned manually because of abnormal udder structure were excluded from the study.

Effectiveness of Teat Cleaning

Cleanliness of the teats was evaluated before and after teat cleaning to evaluate the effectiveness of the teat cleaning procedure. All 4 teats of each cow were visually evaluated by the same experienced person. The side of the teat facing the researcher was evaluated with the help of a flashlight. Teat end was evaluated with the help of a mirror without touching the teat. A 5-point (0 to 4) scoring system for teat cleanliness was created. Teats were scored in categories based on the extent of the area of the teat covered with dirt (Figure 1). Cleanliness score was also treated as a dichotomous variable by classifying teats as clean if they were in the category "clean" or "almost clean" and as dirty otherwise. The location and nature of the dirt were also recorded.

Characteristics of Cows and Teats

During farm visits, parity, DIM, milking frequency, and time since last milking of the cows were recorded. Udder and teat structure, udder hairiness, teat color, teat condition before teat cleaning, and behavior of the cows during teat cleaning were monitored. Characteristics of cows and teats are shown in Tables 1 and 2. If the dimensions of the udder and teats were out of the range recommended by the manufacturer of the AMS, the udder and teat structure was considered abnormal. The dimensions of udders and teats of those cows that appeared not to fulfill the requirements at the time of evaluation were determined with a measuring tape to confirm the abnormality.

Statistical Analyses

All statistics were analyzed using SPSS 11.0. (SPSS Inc., Chicago, IL). Pearson's χ^2 test was used to test