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

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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-

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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

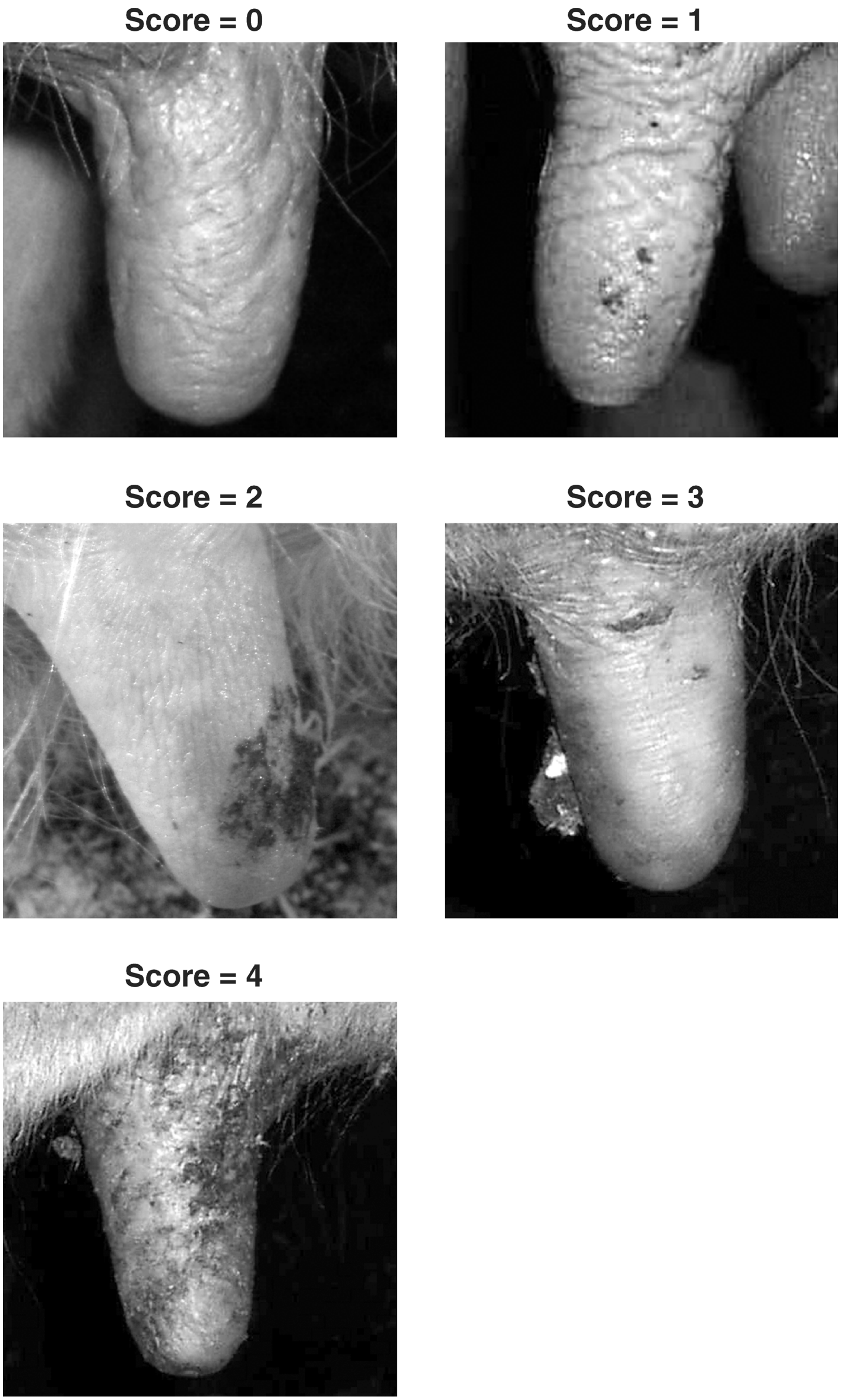

Figure 1. Teat cleanliness scoring system, in which a score of 0 = clean (no visible dirt), 1 = almost clean (approximately <10% of the area dirty), 2 = slightly dirty (10 to 20% of the area dirty), 3 = dirty (20 to 50% of the area dirty), and 4 = extremely dirty (>50% of the area dirty).

Table 1. Characteristics of the cows in Group A (cleaning cup; 161 cows) and Group B (rotating brushes; 184 cows).

		% (Confidence interval)	
Factor	Scale	Group A	Group B
Parity	Second+	69.6 (7.3)	34.6 (7.1)***
Days in milk	>30 d	87.5 (5.2)	89.0 (4.6)
Milking frequency	>2.5 milkings/d	52.2 (8.0)	40.1 (7.3)*
Time since last milking	≥8 h	63.3 (7.7)	79.7 (6.0)**
Behavior of the cow	Restless or standing at one side of the milking stall at the time of milking	6.2 (3.8)	13.6 (5.1)*
Udder hairiness	Udder unshaved, disturbing udder hair (reaches to the teat barrel)	44.7 (7.9)	23.4 (6.2)***

***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

the independence of different variables between groups or the interdependence of the covariates. Confidence intervals at the 95% level were estimated for cell frequencies by normal approximation of binomial distribution. The experimental unit was the teat with the exception of the cow-level characteristics in Table 1 and the cow-level comparison of the groups on the TSTC.

Factors associated with TSTC were studied with a binary logistic regression model. The model was repeated separately for both groups and accounted for the effect of herd and characteristics of the teats and cows. Herd was included to control for the cluster effect of the herds. The initial model was:

Successful teat cleaning = μ + herd + teat location (fore, hind) + parity + DIM + milking frequency + time since last milking + cow behavior + teat color + udder and teat structure + udder hairiness.

Herd (1 to 9) was characterized as categorical variable. All other covariates were dichotomous. Statistically significant ($P < 0.05$) variables were included in the final model and selected with the help of the backward selection procedure of the SPSS.

Cow and herd characteristics associated with ETC were studied with an ordinal regression model with negative log-log link-function. Only teats with technically successful cleaning and teat cleanliness before cleaning > 0 were included in the analysis (a total of 1024 teats). The initial model accounted for the effect of group, herd, and characteristics of the teats and cows and was:

Teat cleanliness after cleaning (0 to 4) = μ + group + herd + teat location (fore, hind) + teat cleanliness before cleaning + parity + DIM + milking frequency + time since last milking + teat color + udder and teat structure + teat condition + udder hairiness + group × teat cleanliness before cleaning + herd × teat cleanliness before cleaning.

Statistically significant ($P < 0.05$) variables were included in the final model.

Table 2. Characteristics of the teats in Group A (cleaning cup; 616 teats) and Group B (rotating brushes; 716 teats).

		% (Confidence interval)	
Factor	Scale	Group A	Group B
Teat color	>50% of the area black	14.4 (2.8)	5.9 (1.8)***
Teat condition	Distinct callosity ring or very dry skin	24.7 (3.5)	10.8 (2.3)***
Udder and teat structure	Abnormal	10.4 (2.5)	13.4 (2.5)
Teat cleanliness before cleaning	0 = clean teat	2.8 (1.3)	6.1 (1.8)**
	1 = almost clean	19.8 (3.2)	24.3 (3.2)*
	2 = slightly dirty	18.7 (3.1)	22.3 (3.1)
	3 = dirty	19.5 (3.2)	20.0 (3.0)
	4 = extremely dirty	39.3 (3.9)	27.2 (3.3)***
Location of the dirt	Barrel	89.9 (2.4)	78.2 (3.1)***
	Apex	72.7 (3.6)	67.6 (3.5)*
	Teat orifice	80.0 (3.2)	54.2 (3.7)***
Nature of the dirt	Manure	89.0 (2.5)	83.4 (2.8)**
	Bedding (shavings, peat, straw)	56.3 (4.0)	39.2 (3.6)***

***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

Table 3. Observed reasons for partly and totally unsuccessful cleanings of Group A (cleaning cup) and Group B (rotating brushes).

	Partly unsuccessful		Totally unsuccessful	
Observed reason for failure	Group A	Group B	Group A	Group B
Unknown, %	65	54	34	42
Behavior of the cow, %	12	21	7	52
Udder and teat structure, %	14	25	7	6
Udder hair, %	9			
Device failure, %			52	
Total number of failures, no.	76	76	44	31
(% of all cleanings per teat)	12.7	10.7	7.4	4.3

RESULTS

Technical Success of Teat Cleaning

For herds using a teat cleaning cup (Group A), an average of 79.9% of teat cleanings were technically successful, whereas herds using brushes (Group B) were technically successful for 85.0% ($P = 0.012$) of the teat cleanings. For Group A, 12.8% were partly unsuccessful and 7.2% were totally unsuccessful teat cleanings; for Group B, 10.6% were partly and 4.3% totally unsuccessful teat cleanings. Proportion of cows that had a successful teat cleaning procedure for all teats was 57.1% in Group A and 60.7% in Group B ($P = 0.514$). In Group B, 63.0% of the partly unsuccessful, and 80.0% of totally unsuccessful cleanings were unsuccessful in both brushings.

The observed reasons for failures are shown in Table 3. Factors associated with TSTC are presented in Table 4. Within Group A, the proportion of technically successful teat cleanings differed markedly among the herds (Wald test value of 40.9 with 4 degrees of freedom, $P < 0.001$). Within Group B, herd did not significantly affect TSTC. The percentage of technical success was from 62.9 to 95.8% of the teats in Group A and from 80.4 to 89.9% in Group B. According to the odds ratios of the logistic regression model, each of the factors associated with TSTC reduce the chances of successful teat cleaning to less than a half. The model could explain on average 97.3% of the successful teat cleanings, and only 7.5% (Group B) or 29.2% (Group A) of the unsuccessful teat cleanings.

For Group A, only 50.0% of the teat cleanings with teat cups were successful if the cow was restless compared with 66.7% success with brushes used in Group B. During early lactation, only 49.3 and 69.6% of the teat cleanings succeeded in Group A and Group B, respectively. Udder and teat structure was associated with TSTC only in Group B, although only 71.4% of teat cleanings succeeded in Group A if udder structure was abnormal. With Group A, only 69.7% of the teat cleanings were successful if the color of the teat was black.

Effectiveness of Teat Cleaning

After cleaning, 33.1% of the teats cleaned with a cup in Group A and 37.1% of the teats cleaned with brushes in Group B were totally clean ($P = 0.168$). After cleaning, 84.5% of the teats in Group A and 80.6% in Group B were considered clean if a dichotomous scale was used ($P = 0.094$). Ordinal regression model showed that group was associated with ETC (Wald test value of Group A was 8.8, $P = 0.003$). Interaction of group and teat cleanliness before cleaning was also associated with ETC (Wald test value for Group A = 30.0, $P < 0.001$; and Group B = 60.3, $P < 0.001$). Effectiveness of teat cleaning differed among herds slightly more than between groups. Interaction term herd × teat cleanli-

Table 4. Factors associated with technical success of teat cleaning (TSTC).

Factors associated with TSTC (Reference group)	Group A		Group B	
	OR[1]	95% CI of OR	OR	95% CI of OR
Teat location (hind)	0.47**	0.29–0.74	0.38***	0.24–0.62
Restless behavior	0.27**	0.12–0.63	0.27***	0.16–0.45
DIM (until d 30 postpartum)	0.25***	0.14–0.45	0.46**	0.25–0.82
Abnormal udder and teat structure	Not associated		0.41**	0.23–0.73
Teat color	0.41**	0.23–0.73	Not associated	

[1]OR = Odds ratio of the factor.

***$P < 0.001$, **$P < 0.01$.

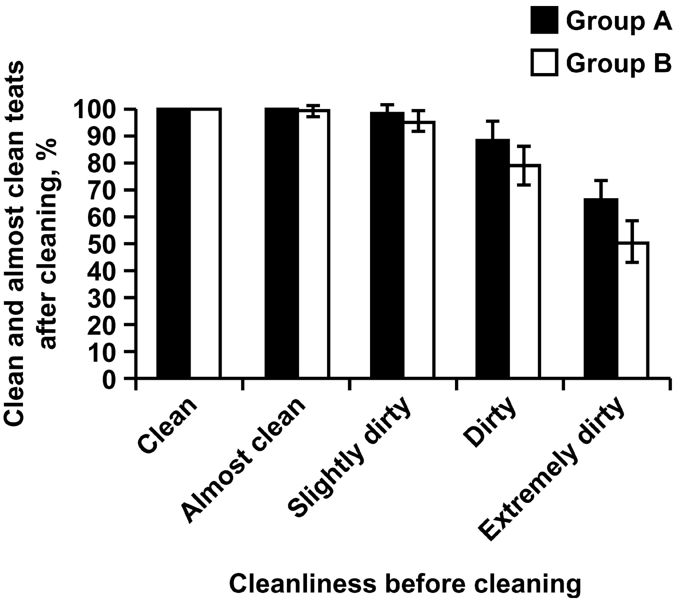

Figure 2. Proportion of clean or almost clean teats after cleaning in different categories of teat cleanliness before cleaning with 2 cleaning methods; cleaning cup (Group A) and rotating brushes (Group B) (with confidence intervals).

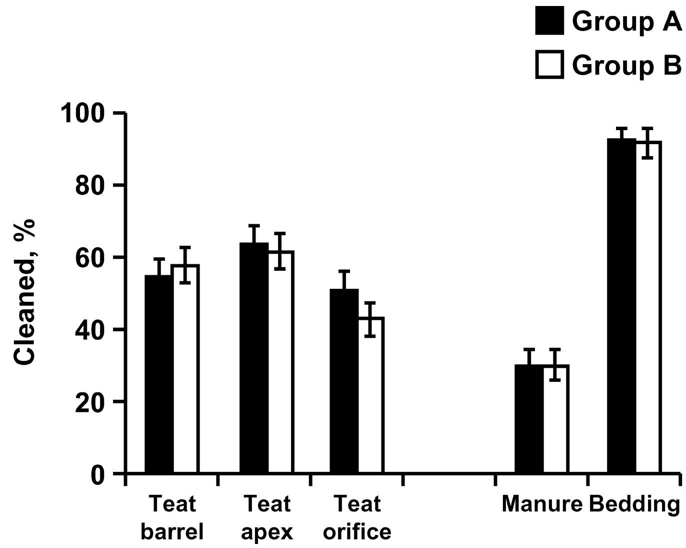

Figure 3. Cleaning of dirt from different locations of the teats and cleaning of manure and bedding (peat, sawdust, or straw) from the teats with 2 cleaning methods; cleaning cup (Group A) and rotating brushes (Group B) (with confidence intervals).

ness before cleaning of only 1 herd was significantly associated with ETC.

Teat cleanliness after cleaning varied mainly according to the cleanliness of the teat before cleaning (Wald test value of change of one cleanliness category was 56.7, $P < 0.001$). Of the extremely dirty teats, 4.8% remained so after cleaning and only 12.9% became totally clean. Extremely dirty teats were mainly almost clean after cleaning (52.7% in Group A and 37.6% in Group B). Figure 2 shows that in Group A, a larger proportion of the extremely dirty teats were clean or almost clean after cleaning ($P = 0.002$). Using a dichotomous approach, of the originally dirty teats 79.8% in Group A and 72.9% of those in Group B were clean after teat cleaning ($P = 0.024$). Only 4 teats were classified as dirtier after cleaning than before cleaning.

From Figure 3, it can be concluded that bedding material on the teats was cleaned almost completely. In Group A, the bedding materials were peat (2 herds), sawdust (2 herds), or no bedding (1 herd). In Group B, sawdust was used in 3 herds and straw in 1 herd. Peat seemed to be cleaned most effectively, and straw least effectively (97.9 vs. 85.7%), but the herds using peat or straw also had more black teats than other farms, which can affect these results. Peat is less visible against black skin than straw. For cows bedded with sawdust, 91.2% of the teats were cleaned. Cleansing of teat orifices was least effective, compared with teat barrel and apex, and teat orifices were less well cleaned in Group B compared with Group A ($P = 0.039$; Figure 3). Teat condition was also associated with ETC (Wald test value = 7.5, $P = 0.006$). Of the healthy teat ends of Groups A and B, 50.4% were cleaned, whereas of the teats having a callosity ring, only 34.3% were cleaned ($P = 0.005$).

DISCUSSION

Technical Success of Teat Cleaning

In this study, the TSTC using AMS was somewhat unsatisfactory for more than one-third of the cows tested. This is a much higher percentage than that of a Norwegian report (Hvaale et al., 2002), where AMS failed in only 10 to 20% of the teat cleanings of the studied cows. In our study, herd was the most important factor affecting the technical success of teat cleaning in herds using a cleaning cup, in which the variation among herds was high. For teats cleaned with brushes, there were more successful teat cleanings at the teat level compared with those cleaned using a cleaning cup, but no differences between groups were found at the cow level. Comparison of the groups has to be made with caution, because of the differences among cows and teat characteristics in the groups and herds. For example, cows that had teats cleaned with a cup (Group A) had more black-colored teats and hairy udders than cows cleaned with brushes (Group B), whose herds had about twice as many restless cows during cleaning as Group A. In Group B, cows were younger and had longer milking intervals than in Group A cows, which might have had a negative influence on the results.

The causes of most of the unsuccessful teat cleanings could not be determined (Table 3). Some of them may have resulted from incorrect programming of the teat coordinates, or by changes in udder structure after programming; however, there is no evidence to support either assumption. The causes for these unsuccessful cleanings are most likely technical. Of defined causes, device failure in all teats of 6 cows in 1 herd in Group A and restless behavior in Group B caused most of the totally unsuccessful teat cleanings, whereas abnormal udder and teat structure caused most of the partly unsuccessful teat cleanings. Most of the unsuccessful brushings in Group B were unsuccessful in both rounds, as also reported by Hvaale et al. (2002), and the potential benefit of more than one brushing would be that teat cleaning would be more effective.

Increased cow restlessness was associated with lower TSTC in both groups. Cows may move after the teat is located by the teat cleaning system in the Group A, teats may slip away from the cup, or the cow may kick the cleaning cup off the teat. With the teat cleaning system used for Group B, cows are expected to stand in the same position as during the last milking and remain motionless. About 10% of the unsuccessful teat cleanings in Group A and 20 to 50% of the unsuccessful teat cleanings in Group B occurred when cows were restless or were standing where the system could not function effectively. Some of the restless behavior might have been caused by the presence of the researchers. However, when working with Group B herds, researchers were standing on both sides of the milking stall, and it would be unexpected for a cow not to be located (more or less) in the middle of the stall. In general, the cows behaved calmly during observation.

More failures in TSTC were found in early lactation, which may be related to restless behavior in some individual postpartum cows (Van Reenen et al., 2002), udder edema, or changing udder shape. Resistance to mastitis is at its lowest level in early lactation (Smith et al., 1985), and therefore milking hygiene is important at that time.

Abnormal udder and teat structure caused some failures in teat cleaning in both groups, although it was significantly associated with TSTC only in Group B. The teat cleaning system of Group A, which locates the teats before teat cleaning, might adjust more flexibly to abnormal udder structure. Closeness of the hind teats, very thick teats, and oblique position of the teat were the most problematic abnormalities in both groups. Due to thick teats, the cleaning device was attached only to the end of the teat. According to Miller et al. (1995), an abnormal distance between hind teats and abnormal distance between fore teats creates the greatest problems in cluster attachment in automatic milking. Problems with TSTC were associated more with hind teats than with fore teats.

Black teat pigmentation was associated with unsuccessful teat cleanings in Group A, where the teats are located with lasers before cleaning. This complication may also cause problems with the attachment of the teat cups as well. Excessively long udder hair was related to a few cases of partially unsuccessful cleanings in 1 herd of Group A, in which an excessive amount of clean, dry bedding material was attached to long udder hair. The AMS pointed the lasers toward the bedding particles and resulted in the teats being folded against the udder base. Parity, milking frequency, and time since last milking were not related to the technical success of teat cleaning in this study.

There is clearly a need to improve the reliability and monitoring methods of TSTC in AMS. Further studies are needed to confirm our findings on the level of technically unsuccessful teat cleanings; for example, by using appropriately located cameras. It would also be interesting to know whether the failures are occasional events or whether they are systematic and possibly related to mastitis or poor milk quality.

Effectiveness of Teat Cleaning

This study clearly indicated that there are deficiencies in the ETC of dirty teats in automatic milking systems. In this study, evaluation of teat cleanliness was visual and, as such, subjective (Knappstein et al., 2002). Nevertheless, our data ought to be internally consistent because one person evaluated all teats. According to Knappstein et al. (2004), using visual evaluation of cleanliness, 69% of the teats appeared visually clean after teat cleaning vs. approximately 35% in our study. The reason for this discrepancy is unclear, but most likely, there is a systematic difference between the evaluation methods. In some experimental studies, teat cleaning with AMS is less effective than manual cleaning (Schuiling, 1992; Knappstein et al., 2004), as effective as manual cleaning (Ten Hag and Leslie, 2002), or more effective (Melin et al., 2002). In field studies with bacteriological and visual evaluation of teat cleanliness, teat cleaning with AMS was less effective than manual cleaning (Knappstein et al., 2004; Tangorra et al., 2004). Teat cleaning in traditional milking is performed manually, and effectiveness depends on the method used and the care of the milker. After a proper manual teat cleaning, there should be no visible dirt on any part of the teat (score of 0 in our study).

Teat cleanliness before cleaning had the greatest influence on ETC. Almost clean and slightly dirty teats were cleaned well, but dirty and, especially, extremely dirty teats were not cleaned well enough—around 45%

of them were left dirty. Almost all teats were visually cleaner or the same after cleaning. In the study of Knappstein et al. (2004), the bacterial counts of the teats in some herds increased during cleaning, particularly if teat contamination was low before cleaning and the teat-cleaning device did not perform ideally or was not clean.

Our finding that there were more differences among herds than teat-cleaning methods on ETC confirms results reported by Knappstein et al. (2004). Our data show that teat cleaning was more effective with a cleaning cup than with brushes, especially for extremely dirty teats. However, Knappstein et al. (2004) found that, based on bacterial counts on the teat skin before and after teat cleaning, extremely dirty teats were cleaned more effectively with brushes, whereas slightly soiled teats were cleaned more effectively with a cleaning cup.

Teat condition affected teat-cleaning efficiency, which is not surprising, as rough teat ends and dry skin harbor pathogens (Neijenhuis, 2004) in automatic as well as in conventional milking. Our study could not confirm the finding by Melin et al. (2002) that hind teats were cleaned more effectively than fore teats with a cleaning cup.

Our finding for Group A and, particularly for Group B, that cleansing of the teat orifice was less effective than that of the teat barrel or apex is critical, as bacteria and sediment on the teat orifice have direct access to the teat canal and to the raw milk collected. According to Jørgensen (1990), the teat apex is the dirtiest part of the teat and is the part in contact with milk during milking.

The great variation among herds provides ample reason to consider corrective actions by management, but there is still a need for development of more effective automated teat cleaning methods. In future studies it would be important to study the effect on ETC of different possibilities for adjusting the teat cleaning sequences of the AMS.

CONCLUSIONS

The proportion of the technically successful cleanings should be much higher than our data indicated. This is possible because 1 herd in the current study registered over 95% technically successful teat cleanings. At present, contrary to Finnish legislation (8/EEO/2002, 2002), automatic milking systems do not alert managers to all technically unsuccessful teat cleanings. The function of the cleaning device can only be evaluated by observing teat cleaning of several cows repeatedly. If there are many unsuccessful teat cleanings (less than 95% of teats successfully cleaned), management action is required. Teat coordinates programmed in the computer should be reevaluated. This is particularly true in early lactation, when postpartum udder edema is decreasing. Cows with poor udder structure should be culled from the herd. Milking should occur smoothly so that it does not cause distress and restlessness. Laser lenses should be kept clean and bright, and udder hair should be kept short. If these management actions are not sufficient, consideration should be given to requesting technical service to address technical issues.

Cleanliness of the teats before cleaning has a significant effect on the effectiveness of teat cleaning. As approximately half of the extremely dirty teats became clean or almost clean in the automatic cleaning process, hygienic measures are of utmost importance. The adjustability of the brush- or cup-cleaning mechanism to suit herd or cow characteristics should be utilized fully. Hygienic maintenance of the milking stable and automatic milking machine can do much to prevent teats from becoming soiled in the milking stall. Good condition of teat skin and opening should be maintained in the herd, and the teat-cleaning device should be clean, intact, and serviced according to the recommendations of the manufacturer.

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