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Milking practices on commercial Holstein-Friesian farms

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ABSTRACT - The objective of this study was to survey and analyze milking practices of commercial Holstein-Friesian farms. A total of 43 Hungarian dairy farms with 31,430 cows was surveyed by using a questionnaire via personal interviews. Furthermore, seven in-depth, individual interviews were conducted with farm managers. In the statistical analysis, we used ANOVA models. The results showed that 57.8% of the milking parlors had a herringbone design, followed by parallel (20.0%) and rotary (17.8%) milking systems. For the interviewed farm managers, gentle (71.4%) and quick milking (57.1%) as well as herd size (57.1%) were the most important factors in determining the milking system design. In 62.8% of the farms, cows were milked twice a day, and the average milking time was 5.0 h with an average of 3.1 laborers. The average daily milking time per cow was 15 min and the average daily walking time per cow to the milking parlor and back was 24 min. Furthermore, 85.4% of the farms used traditional elastic milk liners, whereas 14.6% used silicone ones. In total, 57.1% of the interviewed farm managers said that the ideal teat liner should fit the teats correctly and provide gentle milking. Prior to milking, 65.1% of the farms used disinfectant dip and 11.6% used a disinfectant wash, whereas 23.3% still washed the udder with water. The udder was wiped with paper towels in 73.8% of the herds and with cloth in 26.2% of the herds. Forestripping was performed in all herds: 51.2% onto the floor, 46.5% into a cup, and in 2.3% into a paper towel. Further, 85.7% of the interviewed farm managers considered the use of a cup to be the ideal method, but 57.1% deemed a dark-colored piece of rubber/flooring to be similarly acceptable. Cows with mastitis were milked separately in 91.9% of the farms.

Keywords: dairy cattle, dairy cow, livestock, milk

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1. Introduction

There are several reasons of the growing awareness of udder health issues on dairy farms. In the European Union (EU), the EEC directive 92/46 made in April 1992, stated that milk with a somatic cell count (SCC) over 400,000 cells per mL may not be used for fluid milk. Starting in 1998, this was not used for human consumption. Awareness regarding animal welfare issues also increased. A more recent issue regarding human health concerns antibiotic residues in milk, transfer of antibiotic resistance from animal to human, and transfer of pathogens or products through milk or milk products (Schukken et al., 2003). To prevent mastitis, one should consistently put effort into optimizing nutrition, host resistance, environmental conditions, milking equipment, milking technique, and hygiene (Bradley, 2002; LeBlanc et al., 2006). The association of milking practices with udder health has been extensively studied in various countries (Moxley et al., 1978; Hueston et al., 1990; Bartlett et al., 1992; Goodger et al., 1993; Barkema et al., 1999; Busato et al., 2000; Barnouin et al., 2004; Köster et al., 2006).

Use of practices that control mastitis and regular milking machine maintenance are both commonly associated with lower bulk milk SCC (Rodrigues et al., 2005). Whereas the United States has the National Animal Health Monitoring System to "collect, analyze, and disseminate data on animal health, management, and productivity" (Belage et al., 2017), no similar system is in place in Hungary to benchmark udder health management on dairy farms. Therefore, the objective of our study was to survey milking procedures and analyze the associations between milking practices, milking equipment, herd size, and milk production parameters on commercial Holstein-Friesian farms in Hungary.

2. Material and Methods

2.1. Study design

The survey was drafted to define milking practices on commercial Holstein-Friesian farms and the views of farm managers on udder preparation. The drafted survey was reviewed by farm managers (n = 2), dairy cattle veterinary practitioners (n = 3), academic professionals (n = 3), and veterinary and animal science PhD students (n = 3) to receive feedback on content. Based on collected feedback, revisions were made before the survey was sent to potential respondents. The revised survey was reviewed by the Scientific Research Committee of the Faculty of Veterinary Science, Budapest, and found exempt from human subject protection regulations.

This study used a mixed-method approach, which combines collection and analysis of quantitative and qualitative data. In the first part of this work, we collected data about total number of cows, type of milking system and parlor, number of daily milkings, milk production parameters (lactation milk yield, milk fat content, milk protein content, percentage share of marketed milk, SCC, and days in milk [DIM]), and we also surveyed the udder preparation and milking practices including questions about washing udder prior to milking, wiping udder, udder massage prior to milking, use of pre-milking disinfectants, forestripping into a cup, type of milk liners, and separated milking of cows with mastitis. In the second part of the in-depth survey, structured individual interviews were conducted with dairy cattle farm managers. We used a questionnaire with open-ended questions that allowed the participants to convey their views on the afore-mentioned milking equipment, herd management, and milking practices.

2.2. Data collection

Commercial Holstein-Friesian farms were included in this survey based on the following criteria: use of computerized on-farm records, participation in milk recording, and willingness to provide data to the authors. A total of 43 Hungarian dairy farms were surveyed between September and October 2014 by using a questionnaire via personal interviews with farm managers (n = 21; 48.8%), veterinarians (n = 14; 32.6%), shift supervisors (n = 5; 11.6%), or division heads (n = 3; 7.0%), who had access to farm records and were familiar with the milking procedures in the studied dairy units. Furthermore, we had in-depth, structured individual interviews with seven farm managers (out of the 21). The participants took part in the survey voluntarily and remained anonymous. Each participant was required to sign a written consent before they began the survey. Each questionnaire was coded to detect inaccuracies in data entry. The obtained data were processed in MS Excel (Microsoft Corporation, Redmond, WA, USA).

A total of 31,430 cows were kept on the 43 farms, which corresponded to 17.9% of the 176,000 Hungarian dairy cattle stock according to the official statistical data (HCSO, 2015). The smallest surveyed farm had 56 cows, whereas the largest had 2500; the average herd size was 731±508 (milking + dry cows). All of the seven regions of Hungary were covered in the survey (min. 3 and max. 14 dairy farms per region were involved). The seven, individually interviewed farm managers represented a total of 6,130 cows with an average herd size of 876±779 (n = 7; min. 300; max. 2500).

The annual total milk production per farm was 6,712,655±5,238,316 kg (n = 43; min. 321,484 kg; max. 22,522,000 kg), of which 96.8% was marketed (min. 90.0%, max. 99.3%). The average lactation milk yield was 9,716±1,339 kg (n = 41; min. 5,409 kg; max. 11,915 kg), average milk fat content was 3.7±0.2% (n = 41; min. 2.97%; max. 4.16%), average milk protein content was 3.3±0.2% (n = 41; min. 3.17%; max. 4.2%), and average SCC was 419,000±184,000 (n = 38; min. 188,000; max. 936,000), respectively. The average lactation length was 373±42 days (n = 26; min. 310 days; max. 545 days).

All herds (n = 43) were free from tuberculosis, brucellosis, and bovine leukosis, but 34.9% of the farms were also free from either infectious bovine rhinotracheitis (25.6%), bovine viral diarrhea (4.7%), or the five diseases (4.7%). The diseased cows (e.g., clinical mastitis cases) were kept in separate hospital barns on 59.5% of the surveyed farms (n = 42). In other herds (40.5%), they were isolated within the maternity barn.

2.3. Statistical analysis

The surveyed farms represented all farm sizes, milking systems, milking parlor types, and geographical regions in Hungary. Milking practice outcome measures were analyzed with ANOVA models. All models included the herd size (1-400, 401-800, and >800 cows), milking parlor type (herringbone, parallel, rotary, polygon), and number of daily milkings (two times, more than two times) as explanatory variables. Consequently, bias caused by data imbalance related to these variables were eliminated from the resulting estimates. For each milking practice outcome, the basic model included only the three main management variables listed above. Next, each management explanatory variable was added to the basic model one by one separately (Table 1). Differences between the means of the outcome variables in the layers of the basic explanatory variables, farm size, and milking parlor were evaluated by Tukey's multiple comparison method applying the R package multcomp. Statistical analyses were performed in R version 4.0.4 (R Core Team, 2020). The level of significance was set to 0.05.

Table 1 - The analyzed milking practice management explanatory variables

Variable	
Washing udder prior milking	Yes
	No
Wiping udder	Cloth
	Paper
Udder massage prior to milking	Yes
	No
Use of premilking disinfectant	Yes
	No
Forestripping in a cup	Yes
	No
Milk liner	Elastic
	Silicone
Separated milking of mastitis cows	Yes
	No

3. Results

3.1. Milking equipment

DeLaval milking systems were used most frequently (31.0%) on the farms, followed by BouMatic (21.4%), while eight different types of milking systems were installed on the remaining farms

(Figure 1). There was no significant relationship between herd size and the studied milk production parameters (lactation milk yield, percentage share of marketed milk, DIM, SCC; P≥0.0892). More than half of the milking parlors had a herringbone design (57.8%), followed by parallel and rotary milking systems (20.0 and 17.8%, respectively) (Figure 2). No significant association was found between milking parlor type and milk production parameters (P≥0.0728). The average age of the milking systems was 11.7 years (n = 41; min. 1 year; max. 28 years).

The personally interviewed farm managers mentioned gentle (71.4%) and quick milking (57.1%), as well as herd size (57.1%), as the most important factors determining the milking system design or technique, while economical operation, safety, and long service time were mentioned only once (14.3% each). Three out of the seven interviewed farm managers (42.9%) emphasized the importance of the distributor and the easy-to-use characteristic. Two of them (28.6%) chose reliable service and individual data management.

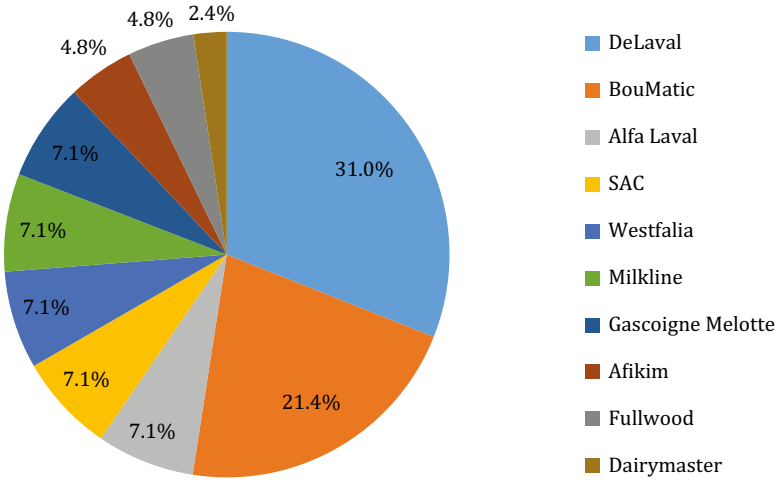

Figure 1 - Type of milking system (n = 42).

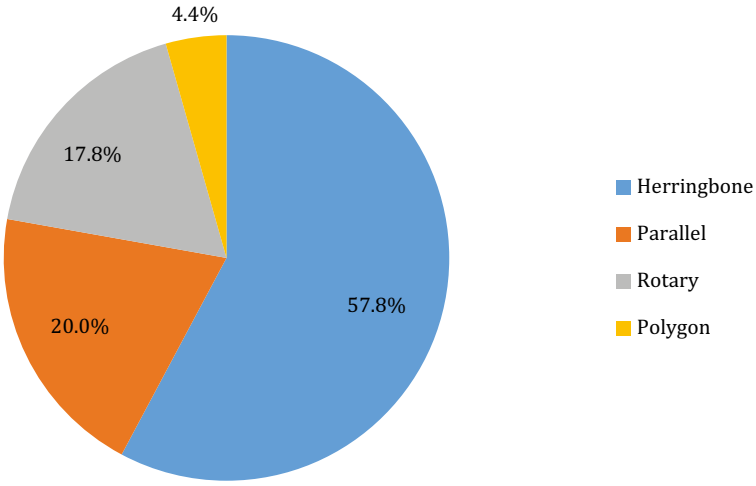

Figure 2 - Type of milking parlour (n = 43).

3.2. Herd management

Most commonly (62.8%), cows were milked twice a day, but in 41.9% of the farms the cows were milked three times and four times a day in 4.7% of the farms. The number of daily milkings showed

significant association with lactation milk yield (P = 0.0132). On four farms (9.6%), different cow groups were milked differently (usually cows were milked more frequently until 30 DIM). The average milking time was 5.0±1.5 h in the herds (n = 41; min. 1 h; max. 7.5 h) with an average of 3.1±1.1 laborers working during a session (n = 42; min. one laborer; max. six laborers), including the laborers walking the cows up to the milking parlor. The average daily milking time per cow was 15±5.4 min (n = 40; min. 5 min; max. 27.7 min), and the average daily walking time per cow to the milking parlor and back was 24.0±16.8 min (n = 39; min. 3 min; max. 87 min).

Five out of seven interviewed farm managers (71.4%) agreed that the optimal number of milking sessions was twice a day, because it is cost-efficient easier to serve the cows' needs (28.6%), makes organizing work simpler (14.3%), and lowers the number of mastitis cases (14.3%). The other two farm managers (28.6%), who were in favor of three milking sessions, said that significantly more milk can be produced this way (28.6%), while the cows still have enough time to rest, and organizing the work well is also feasible (14.3% each).

3.3. Milking practices

The vast majority of farms (85.4%) used traditional elastic milk liners and 14.6% silicone ones. The silicone milk liners tended to be associated with larger lactation milk yield than the elastic ones (P = 0.0633). According to four out of seven interviewed farm managers (57.1%), the ideal teat liner should fit the teats correctly and provide gentle milking. Two out of seven (28.6%) also mentioned durability as an important factor and tended to prefer replica replacement parts of the manufacturers because of the significantly lower price and almost identical quality. One farm manager said that the ideal liner should be original, easy to clean, and depend on the milking technique and the distributor recommendation (14.3% each).

The teat cups were disconnected automatically on all farms, except for the smallest one. Every interviewed farm manager agreed that it is reasonable to disconnect the teat cups automatically, because none of them experienced overmilking and three of them (42.9%) said that the milking process was significantly quicker.

Prior to milking, 65.1% of the farms used disinfectant teat dips, whereas 11.6% used a disinfectant wash, and 23.3% still washed the udder with water. Wet paper towels (16.3%) and wet cloths (4.7%) were also relatively commonly used to prepare the udder for milking (Figure 3). The udder was wiped with paper towels in 73.8% of the herds, the other farms used cloth (26.2%). Four out of seven

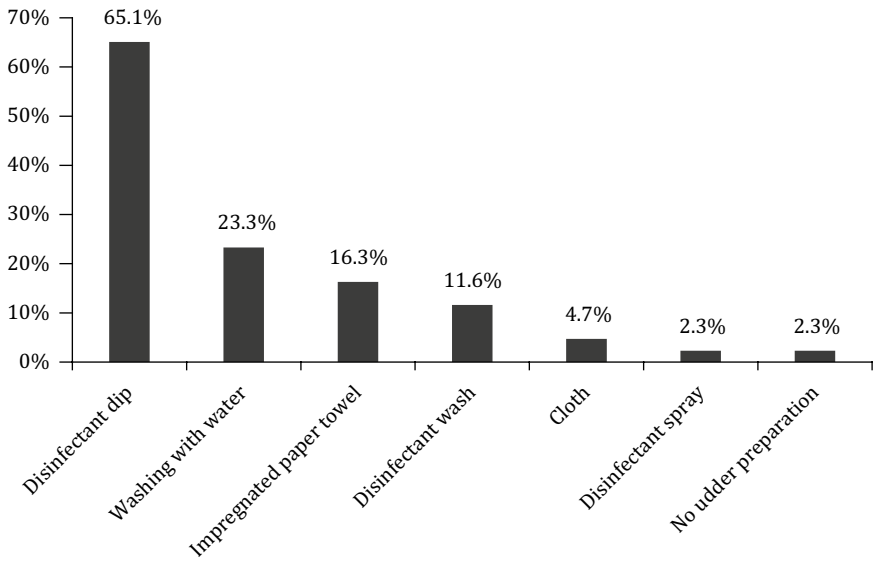

Figure 3 - Pre-milking udder preparation (n = 43).

interviewed farm managers (57.1%) considered a foaming disinfectant wash or a disinfectant dip followed by wiping the udder with a paper towel to be the ideal method for udder preparation, while six out of seven farm managers (85.7%) said that pre-milking disinfection should always be used for udder preparation. Only one interviewed farm manager (14.3%) said that wiping with a paper towel was enough to prepare the udder for milking.

Udder massage before milking was not performed in most of the herds (62.0%), and only two out of the seven farm managers (28.6%) considered it to be important before milking to stimulate the release of oxytocin. According to the other five managers (71.4%), the udder is well-prepared for milking even without udder massage because udder preparation (e.g., disinfection, wiping) provides the necessary stimuli and the time needed for the let-down of milk. No association was found between the studied milking practices and SCC, but udder massage prior to milking was estimated to decrease SCC the most (−107,720/mL) compared with no massage ($P \geq 0.1504$).

Forestripping was performed in all herds, 51.2% onto the floor, 46.5% into a cup, and in 2.3% into a paper towel. All seven interviewed farm managers considered forestripping to be essential; five out of seven (71.4%) considered detecting clinical mastitis, three (42.9%) considered removing the "teat plug", and two (28.6%) considered recognizing changes in milk. Further, six out of seven farm managers (85.7%) considered the use of a cup to be the ideal method, but four (57.1%) deemed a dark-colored piece of rubber/flooring to be similarly acceptable.

Cows with mastitis were milked separately in 91.9% of the farms, but unfortunately, there were herds where they were milked together with the healthy cows (5.4%). In 2.7% of the farms, they were only milked separately if their number exceeded a certain limit. All seven interviewed farm managers agreed on the importance of milking the cows with mastitis separately, primarily to avoid reinfections (71.4%) and to prevent residues in milk (57.1%). However, the easier and more efficient treatment of the cows (28.6%) and successful *Staphylococcus aureus* eradication (14.3%) were also mentioned as important reasons for separating cows with mastitis.

4. Discussion

4.1. Milking equipment

The average dairy herd size was 731 cows, but varied from 56 to 2500 cows, and large differences could be seen in milking technology. Nipers et al. (2016) recommended a separate parlor for 200 cows. However, the Hungarian farms with a smaller number of cows had already used separate milking parlors (Ivanyos et al., 2020). The prevailing loose housing dairy farms mostly used two technologies: herringbone and rotary milking parlors (Priekulis and Kurgs, 2010). Nevertheless, in Hungary, the most commonly used type of milking parlors was the herringbone (71.0%), followed by the parallel (14.9%), rotary (9.6%), and others (4.6%) (Ivanyos et al., 2020), which distribution was found by this study, as well.

4.2. Herd management

The number of milkings per day was extensively studied in the past. Cows milked three times a day produced 20% more milk on average than cows milked twice (Woodward, 1931). The change from two to three milkings per day increased the production per lactation by 6-25% (Amos et al., 1985; DePeters et al., 1985; Allen et al., 1986; O'Brien at al., 2002). The negative impact on animal health of milking cows three times a day might not be the direct effect of more milkings, but the pure animal health management of the farm (Armstrong et al., 1985). According to Wall and McFadden (2008), increased milking frequency does not adversely affect the health and reproductive performance of cows and can, therefore, be considered as a potentially profitable technology. The number of daily milkings increased with herd size; thus, 60.0% of the farms with more than 600 cows milked the cows three or four times a day (Ivanyos et al., 2020). With proper milking technology and routine,

three milkings a day could result in higher milk production and smaller incidence of mastitis, but the operating costs are usually higher, which could finally decrease the farm's profitability. Therefore, a thorough economic analysis is recommended before increasing the number of milkings from two to three times a day (Seres and Ózsvári, 2014; Ivanyos et al., 2020). The number of milkings per day depends on many factors, and each farm should analyze their own environment to choose the best option that satisfies both animal health and financial requirements.

Bach et al. (2008) did not find any relationship between milk production and the amount of time devoted to milking the cows. In that study, the total daily time devoted to milking was, on average, 3.1 h with a much smaller average herd size (68 cows). We found that the average milking time was 5.0 h in the surveyed large Holstein-Friesian herds with an average herd size of 731. The permeability of the milking parlor can be influenced by the number of stalls, while the operators' effectiveness can be influenced by factors such as milking routine and average milking yield of cows (O'Brien et al., 2012; Edwards et al., 2013). The number of operators in our study ranged between one and six, which can be explained by the different type of parlor, the various number of stalls and cow groups, and the diverse distances between the parlor and barns (which were not studied in this research).

4.3. Milking practices

A high milking performance level is often related to an impact on the teat tissue caused by vacuum or liner compression, which can lead to pathological dimensions of congestion of the tissue or hyperkeratosis as a long-term effect (Odorcić et al., 2019). Several authors stated that the liner selection is one of the main influences over milk flow rate without directly referring to liner compression (Gleeson et al., 2004; Mein and Reinemann, 2009; Ambord and Bruckmaier, 2010). Automatic cluster removal and earlier detachment of the unit at a relatively high milk flow level allows farmers to reduce the influence of higher claw vacuum levels on the tissue at the end of milking without negatively affecting milk yield or milk composition (Odorcić et al., 2019). All things considered, it is recommended to use proper milk liners fitting to the animals' condition, and the liners should be monitored regularly and, if necessary, be changed to prevent teat tissue damages and hyperkeratosis.

In the past, the commonly used pre-milking teat preparation method involved washing teats by hand with water and drying teats with a paper towel just before the machine was attached (Ingawa et al., 1992). There is strong evidence that among all pre-milking procedures, wet cleaning followed by manual drying with a paper towel results in the lowest bacterial counts (Galton et al., 1982; Galton et al., 1986; McKinnon et al., 1990; Gibson et al., 2008). As an alternative to washing and drying teats, many milk producers now dip teats pre-milking with various disinfectant products (Galton et al., 1986; Ingawa et al., 1992; Oliver et al., 1993; Foret et al., 2005; Gibson et al., 2008; Martins et al., 2017). If the herd infection level is high and the risk of spread of infection is greater, then there may be a benefit of pre-milking teat disinfection of clean teats, followed by teat drying. However, the routine application of pre-milking teat disinfectant in pasture-grazed herds is unlikely to be of benefit when herd SCC is below 200×10^3 cells/mL (Gleeson et al., 2018). Gibson et al. (2008) concluded that most pre-milking teat cleaning treatments reduce the teat total bacterial count, but that cleaning effectiveness was influenced by the type of disinfectant and application methods. In general, when cows were housed indoors, the procedure was found to reduce the incidence of new intramammary infections caused by environmental pathogens by more than 50% (Gleeson et al., 2018).

Washing with water is only indicated when the udder is very dirty, but it is not recommended as a routine part of udder preparation (Skrzypek et al., 2004). If the udder is wiped with dry paper towels, this procedure cannot play a role in spreading infections (Gibson et al., 2008). The use of pre-milking disinfection should definitely be used on those farms where the overall infection pressure is high to prevent new infections during milking, but its practical application has to follow the instruction manual and be monitored regularly.

Forestripping is typically recommended to detect clinical mastitis and is also a mean of pre-milking stimulation (Wagner and Ruegg, 2002). The application of forestripping is well-established in mastitis

control programs (Rodrigues et al., 2005) as it facilitates the rapid detection of clinical mastitis allowing for the prompt treatment and, therefore, increased likelihood of successful outcomes (Hillerton and Semmens, 1999). Although forestripping is important to decrease the incidence of contagious pathogens, it also plays a role during milking preparation to stimulate milk let-down (Bruckmaier and Blum, 1996). Forestripping is a mandatory practice in Canada for farms under the Canadian Quality Milk program. Producers are required to inspect the milk of each cow before it can be added to the bulk tank. However, a significant proportion (19%) of Canadian producers did not forestrip during milking preparation (Belage et al., 2017). In our study, forestripping was performed in all 43 herds, the only difference was stripping into a cup (46.5%), on a paper towel (2.3%), or onto the floor (51.2%). Forestripping is an important step in mastitis detection and stimulates the udder before milking. The presence of the forestrip should be controlled during milking to reach proper udder health and milk quality on dairy farms.

5. Conclusions

The selection of appropriate milking system depends on many factors, but gentle and quick milking, as well as herd size, are very important aspects in this farm management decision. Albeit most of the farms use traditional elastic milk liners, the silicone ones can be associated with larger lactation milk yield, probably because they fit the teats better and provide more gentle milking. Three and four times a day milking significantly increased the lactation milk production compared with milking twice a day on the surveyed farms. At the same time no associations were found between the studied milking practices and the lactation milk yield, percentage share of marketed milk, days in milk, and somatic cell count, while the udder massage prior to milking was estimated to decrease somatic cell count the most. Forestripping was performed in all surveyed herds, and more than three-quarters of the farms used pre-milking teat disinfectants and milked cows with mastitis separately. All things considered, to achieve good udder health, a fitting pre-milking protocol and its regular control is a must in commercial Holstein-Friesian herds.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: L. Ózsvári and D. Ivanyos. Data curation: L. Ózsvári. Formal analysis: L. Ózsvári. Funding acquisition: L. Ózsvári. Methodology: L. Ózsvári. Writing-original draft: L. Ózsvári and D. Ivanyos. Writing-review & editing: L. Ózsvári.

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