EFFECT OF MILKING PROCEDURES ON MILK SOMATIC CELL COUNT

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ABSTRACT. *Data were collected from five dairy farms, where cows were milked with pipeline milking system. These agricultural enterprises were interested in monitoring and analysis of milkers' working time consumption, to make sure they follow all the machine milking regulations. On three farms the cows were milked using De Laval and on two farms with Rezekne pipeline milking equipment. The De Laval milking system was supplied with automatic cluster remover (ACR). This type of milking equipment enables the milkers to more properly milk the cows. On all dairy farms the cows were milked twice daily.*

*Monitoring of the work activities of 24 machine milking operators, who milked the cows selected for our trials, was carried out immediately after control-milking. The duration of each element of the working process was recorded. Data on milk, fat and protein yields, and somatic cell count were collected. The mean duration of pre-milking udder preparation was 30 sec/cow, which did not meet physiological demands of cows during machine milking. Some cows were prepared only for 11 seconds, whereas the udder preparation comprised merely inadequate cleaning of teats, and foremilk was not stripped out. The maximum duration of over-milking was 103 seconds. A significant positive correlation (r=0.356***) was observed between the unit attachment to the cow and machine stripping. The milking operators, who were late in unit attachment, spent considerably more time on machine stripping. All the basic milking procedures had an impact on milk somatic cell count. A significant correlation was observed between over-milking time and somatic cell count as well as between pre-milking udder preparation and milk SCC (P<0.001).*

Keywords: *somatic cell count (SCC), procedures in machine milking.*

Introduction

The success of the modern dairy farm depends on the profitable production of high quality milk. Important factors for the prevention of high milk somatic cell count (SCC) are: post-milking teat disinfection, dry cow therapy, good milking management, treatment of clinical mastitis with antibiotics, and culling of problem cows (Barkema *et al*., 1998). Researchers (Merril *et al*., 1987) have determined that a twelve-hour interval between milkings is optimal in the case of twice daily milking. A correct milking routine includes different working operations: teat and udder cleaning, manual pre-stimulation, fore-milking, milking unit attachment to the cow, removal of milking unit, and effective post-milking teat disinfection (teat dipping). The investigations (Calhoun, 1995) have indicated that more than 50% of the working time is spent on milking. Nowadays the milking process is largely mechanised. Improper and careless milking may result in decreased milk let-down, increased incidence of udder diseases and low milk quality, which are ultimately causing considerable economic loss for dairy producers.

Somatic cell count, or a parameter derived from this count, is often used to distinguish between infected and uninfected quarters. It has been found that 200,000 cells/ml is the most practical threshold to determine the profitability of dairy farms (Harmon, 1994; Heald *et al*., 2000; Haile-Mariam *et al*., 2003; Rogers, 1995). Somatic cells are also present in milk of healthy cows, and the increase in SCC is a normal cellular defence against udder infections (Koivula, 2005). Most countries do not widely record clinical mastitis incidences (Emanuelson *et al*., 1988; Lund *et al*., 1999). SCC is objectively recorded on a continuous scale, and it has a higher heritability than mastitis incidence (Kennedy *et al*., 1982; Pösö, Mäntysaari, 1996; Schepers, 1997; Koivula *et al*., 2004). The year 1979 was the beginning of somatic cell count registering in Estonia and from 1987 these data are measured and registered monthly in Estonian milk recording scheme (Pentjärv, Uba, 2004). Herds with high somatic cell count must adopt a short-term goal of reducing SCC as quickly as possible so that milk can be legally marketable and dairy cattle breeding sustainable. More and more attention is paid to milk quality. After the accession of Estonia to the European Union, the demands on milk quality were in compliance with the proposed EU legal limit of 400,000 cells/ml. Similar levels are required in New Zealand and Australia, whereas Canada established the requirement of a SCC < 500,000 cells/ml (Sargeant *et al*., 1998; Norman *et al*., 2000).

Estonia faces several problems with somatic cell count affecting milk quality and udder health. In 2004, 26% of cows were culled due to udder diseases, and mean milk somatic cell count was 361,000–435,000 cells/ml on dairy farms in Estonia (Jõudluskontrolli…, 2005). These circumstances give reasons to investigate the influence of milking procedures on somatic cell count in milk.

Material and Methods

Data were collected from five dairy farms, where cows were milked with pipeline milking system. These agricultural enterprises were interested in monitoring and analysis of milkers' working time consumption, to make sure they follow all the machine milking regulations. On three farms the cows were milked using De Laval and on two farms with Rezekne pipeline milking equipment. The De Laval milking system was supplied with automatic cluster remover (ACR). This type of milking equipment enables the milkers to more properly milk the cows. On all dairy farms the cows were milked twice daily.

Monitoring of the work activities of 24 machine milking operators, who milked the cows selected for our trials, was carried out immediately after control-milking. The duration of each element of the working process was recorded. Data on milk, fat and protein yields, and somatic cell count were collected. The milking routine included the following:

1. Pre-milking udder and teat preparation (cleaning, washing, drying, massaging and stripping for early detection of clinical mastitis).
2. Cluster attachment.
3. Control of the milking unit and the cow's udder during milking.
4. Over-milking.
5. Machine stripping.
6. Shutting off the vacuum and cluster removal from the cow.
7. Washing of the milking unit.
8. Washing hands and cloth towel.
9. Teat dipping in the sanitising solution immediately after milking.

Additionally were registered the 'transition', i.e. the time a milking operator proceeded from one work operation to another, and the moments when the operator was involved in other activities. Stoppages and undone work operations were also fixed.

MS Excel and SAS program were used for data processing.

Results and Discussion

Present-day milking machines enable the operators to milk cows fast and so that all four udder quarters are milked out. At the same time the regulations of machine milking procedures must be followed. To ensure complete udder evacuation, it is essential to perform careful pre-milking udder preparation, which will induce the release of oxytocin (Bruckmaier, 2000). Adkinson *et al*. (1988) investigated milk somatic cell count in 30 Virgina dairy cattle herds and registered the udder preparation for milking. The analysis of the results revealed, that using of disposable paper towels reduces milk somatic cell count, eliminating the possibility of bacteria transmission from infected cows to healthy ones. The similar result was reported by Randy *et al.* (1990). All studies are consistent in showing that during pre-milking procedures it is necessary to use individual paper towels, especially in these dairy cattle herds where are frequent problems with high somatic cell count in milk.

It is essential to attach milking unit to a cow promptly. The longer is the delay in cluster attachment, the shorter will be the milking time with milk ejection (Merrill *et al*., 1987; Barkema *et al*., 1998). After the unit attachment delay the milk ejection is slow, the udder is not emptied and the machine stripping is abnormally long-lasting (Etgen *et al*., 1987). If the cow is milked at the beginning and in the middle of lactation, it is suggested that the milking unit be attached within 50 seconds after beginning udder preparation. At the end of lactation, it is recommendable to attach the milking unit to a cow a little later (Bruckmaier, 2000).

Table 1. Duration of the basic milking procedures (sec)

Items	Mean	Standard deviation	Minimum	Maximum
Udder preparation	24.0	6.8	11.0	49.0
Delay in milking unit attachment	5.9	8.9	0	43.0
Machine stripping	22.1	9.7	0	54.0
Over-milking	26.3	24.3	0	103.0

As soon as the milk flow has finished, the milking unit must be removed to prevent over-milking, which is one of the most considerable factors causing mastitis infection. Correct time for machine stripping is when the milk flow is changed incomplete and will start to decrease (Etgen *et al*., 1987; Randy *et al*., 1990; Timmermans, 1996). Over-milking may occur immediately after the unit attachment, when the cow's milk let-down reflex is not sufficiently initiated (Calhoun, 1995). The influence of over-milking on milk somatic cell count is also confirmed by Wesen and Schultz (1970).

Numerous studies have been carried out to investigate the optimum duration of machine stripping. With regard to this problem, Reneau (1986) recommends that the machine stripping should last no more than 30

seconds, whereas Etgen *et al*. (1987), Barkema *et al*., (1998) and Calhoun (1995) suggest spending no more than 20 seconds. When the udder is prior adequately prepared for milking, 10–15 seconds of machine stripping per cow is sufficient. Milking operator massages the udder only to control if the milking process has ended properly.

If the udder preparation is insufficient, the machine stripping lengthens significantly (Adkinson *et al*., 1988; Etgen *et al*., 1987). It was also emphasized that if plenty of milk will remain in the udder, the milk yield will decrease in the next milking. Calhoun (1995) and Timmermans (1996) considered the long-lasting machine stripping to be characteristic to the work of these milking operators who devoted less time to udder preparation.

Over-milking of cows occurred with one operator using too many milking units, i.e. four or more units in pipeline milking system (Calhoun, 1995).

Transition from conventional to machine milking increased the infection rate of mastitis. A teat dip was taken into use in the United States in 1916 to reduce the risk of mastitis and the risk of spreading pathogens. Randy (1990), Nickerson *et al*. (1990), Etgen *et al*. (1987), Erskine *et al*. (1998) and Barkema *et al*. (1998) recommended the post-milking teat dip to prevent udder diseases.

Schukken and Schultz (1992) investigated the importance of post-milking teat dip in reducing mastitis infections. In the United States, 74% of dairy farmers applied post-milking teat dip, and obtained most effective results in the case of *Streptococcus agalactiae* and *Staphylococcus aureus*. Some authors, such as Randy *et al*. (1990), Wesen and Schultz (1970), Timmermans (1996), and Erskine *et al*. (1998) recommended that post-milking teat dip should be applied only in cows with increased milk somatic cell count. On the other hand, Etgen *et al*. (1987), Roest (1995) and Hogeveen (1997) considered it to be useful that post-milking teat dip was applied in all cows during each milking, immediately after cluster removal. Nickerson *et al.* (1990) observed that in 16 dairy cattle herds of Wisconsin State in the USA, the post-milking teat dip considerably lowered the somatic cell count in milk. Thus, dipping all teats after each milking has a great impact on reduction of milk SCC.

Another problem is the teat dipping method – either dip into a deso cup or spray teats with a safe and effective disinfectant solution. According to Wesen and Schultz (1970), Watts *et al*. (1984), Randy *et al*. (1990), and Nickerson *et al*. (1990), most effective coverage may be attained by dipping into a deso cup. Teat spraying with disinfectant solution results in larger loss.

Table 1 presents the duration of the basic work procedures of a milking operator. The mean duration of pre-milking udder preparation was 30 sec/cow, which did not meet physiological demands of cows during machine milking. Some cows were prepared only for 11 seconds, in which case the udder preparation comprised merely inadequate cleaning of teats, and foremilk was not stripped out.

Attachment of milking unit to a cow was often delayed, even up to 43 seconds. Due to this, a quarter of the best time of milk let-down was wasted. There were several days of observation, however, during which the unit attachment delay was not registered.

Even 54 seconds were devoted to machine stripping. These milking operators, who economized time in pre-milking udder preparation, devoted more time to machine stripping. Because of incorrect machine milking procedures, cows are used to deliver some quantity of milk by machine stripping.

It was also studied how the milking operators are able to monitor the working process of milking units. As shown in Table 1, they did not manage following each milking unit with sufficient attention, as far as over-milking was observed in several cows. The maximum duration of over-milking was 103 seconds. During such a long time vacuum may cause damage to the secreting tissue of udder quarters.

Teat dipping was used by 19 milking operators out of the 24 participating in the monitoring focused on the work operations of milkers. The other five operators applied this procedure in milking process occasionally. In all cases the method used for post-milking teat dipping was a teat dip into a deso cup filled with the disinfectant solution.

Researchers who have investigated the physiology of machine milking recommended that enough time should be devoted to milking procedures. Relationships between work operations performed during machine milking were studied (Table 2).

Table 2. Relationship between work operations in machine milking

Item	Machine stripping	Over-milking	Delay
Udder preparation	–0.294***	–0.429***	–0.235***
Delay in attachment of a milking unit	0.356***	0.432***	
Over-milking	0.597***		

It was pointed out in the requirements of machine milking physiology that while a milking operator devoted sufficient time to the pre-milking udder preparation, he did not spend enough time on machine stripping (r=–0.294***). The shorter was the pre-milking udder preparation, the more time took the machine stripping.

A significant positive correlation (r=0.356***) was observed between the delay in application of a milking unit and machine stripping. Milking operators, who are late in milking unit attachment to the cow, spend considerably more time on machine stripping. A milking unit attachment, after the cow's milk let-down has

completed, will result in a short-range machine stripping. In this occasion the machine stripping has only the function of emptying the udder quarters. Regarding udder health, this procedure in milking is highly acceptable. It is also apparent from the data in Table 2 that if the milker ignores a single milking procedure, this will influence the rest of milking procedures as well.

Correlation analysis was used to estimate the importance of a certain routine to be followed in a milking process.

Table 3. Correlation between the items

Item	Udder preparation	Delay in attachment milking unit	Machine stripping	Over-milking
SCC, 10^3/ml	–0.304***	0.192***	0.267***	0.422***
Milk, kg	0.096**	0.092**	0.061*	–0.051
Fat, %	0.060*	–0.085*	–0.012	–0.019
Protein, %	0.083*	0.091	0.027	0.025

Table 3 reveals the correlations between the items. All the basic milking procedures influenced the milk somatic cell count. A significant correlation was found between over-milking time and somatic cell count ($P<0.001$). Hence, the less the milking machines were followed, the higher was the somatic cell count per millilitre of milk, resulting from overmilking of teats. In practice, it is important to make sure how many milking units can be adequately handled by one milking operator during milking process.

A significant relationship was also observed between udder preparation for milking and milk SCC. The shorter was the udder preparation for milking, the higher was the milk somatic cell count ($P<0.001$). Insufficient udder preparation, in the result of which more rest milk will remain in the udder at the end of the milking operation, increases the risk of mastitis.

It appeared, based on the data analysis, that the delay in the milking unit attachment had an impact on the milk somatic cell count ($r_p=0.255$***).

A relationship between machine stripping and milk SCC was also found. The more time a milking operator spent on machine stripping, the higher was the milk somatic cell count ($P<0.001$). Cows become used to machine stripping, whereas it will develop the habit of waiting for the operator before milk let-down. In such a way some udder quarters are being overmilked, whereas it cannot be seen from how many udder quarters the milk is flowing. Vacuum damages the gland tissue of the udder quarters which are overmilked.

Relationships between the basic milking procedures, milk yield, and fat and protein content were observed. Most significant correlation was found between milk yield and the cow preparation for milking. These data confirm that a sufficient pre-milking cow preparation is highly important. Thus, the milking operators who had accomplished correctly the pre-milking cow preparation, obtained higher milk yields.

A statistically constant negative correlation ($r_p=-0.096$***) was found between milk yield per cow and the delay in milking unit attachment, which means that longer machine stripping results in getting some extra milk.

As to observing the machine milking regulations, the milk fat content was most significantly affected by udder preparation for milking and delay in milking unit attachment to the cow ($P<0.05$). In case there was a delay in applying the milking unit, a certain amount of milk was not milked out as the time of milk let-down had not been fully utilized. The investigations have shown that the fat content of milk, secreted at the end of milking process, is higher than that of the milk of the early phase of milking.

Regarding milking procedures, the most important factor affecting milk protein content was the udder preparation for milking ($P<0.05$).

Conclusions

The aim of the present study was to investigate the effect of milking procedures on somatic cell count in milk. Data were collected from five dairy cattle farms, where cows were milked with pipeline milking system. These agricultural enterprises were interested in monitoring and analysis of milkers' working time consumption to make sure they follow all the machine milking regulations. On three farms the cows were milked using De Laval and on two farms with Rezekne pipeline milking equipment. The De Laval milking system was supplied with automatic cluster remover (ACR). All dairy cattle farms applied twice daily milking.

MS Excel and SAS program were used for data processing.

The data analysis indicated that all the basic milking procedures affected milk somatic cell count. A significant relationship was observed between over-milking and milk SCC ($P<0.001$). The shorter was the udder preparation for milking, the higher was the milk SCC ($P<0.001$), which proves that the delay in applying the milking unit to the cow has an impact on the milk SCC ($r_p=0.255$***). The more time a milking operator spent on machine stripping, the higher was the milk SCC ($P<0.001$).

Acknowledgements
The authors acknowledge the Council of Scientific Competence, research topic No. 0422102s02, Applied Research of Estonian Ministry of Agriculture No. L0036LKVL04.

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