Effect of pre-stimulation on milk flow pattern and distribution of milk constituents at a quarter level

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ABSTRACT: The aim of this study was to investigate milk flow patterns and milk composition in relation to premilking udder stimulation. The milk of one quarter of each of the sixteen cows was removed separately and in the course of milking it was divided into six fractions (P – cisternal milk during milking without stimulation and the first 300 ml during milking with pre-stimulation, 0–25%, 25–50%, 50–75%, 75–100%, 75–100%, MS-machine stripping) and into five portions (25%, 50%, 75%, 100%, 100% + MS). Two milkings were performed during two consecutive evening milkings with or without manual stimulation. Pre-stimulation resulted in a reduction of milking time, duration of the increase and decline phase of milk flow, stripping yield, but it increased the peak flow rate as compared to milking without pre-stimulation ($P < 0.05$). In both fractions and portions the content of fat increased steadily during milking and reached a maximum at MS. Lactose increased from P to 50–75% and then it decreased to MS. Significantly higher fat contents at 25% and 50% portions and in both protein and dry matter at 25% portions were found during milking with pre-stimulation as compared to no stimulation ($P < 0.05$). The content of fat, protein and dry matter were also higher in both P and 0–25% fractions for milking with pre-stimulation ($P < 0.05$). Pre-stimulation positively influenced the parameters of milk flow and therefore the efficiency of milk removal and contributed to better distribution of components in milk fractions during milking.

Keywords: dairy cows; milking; stimulation, quarter; milk flow; milk constituents

Only the milk stored in the cisternal part of the udder is available for machine milking before milk ejection. Due to a high portion of milk stored in the alveolar part (more than 80%) the occurrence of milk ejection induced by tactile stimulation of the udder before milking is required for complete and fast milk removal. The normal milking liner pulsation also induces the milk ejection reflex during milking. However, the full milking vacuum after the removal of cisternal milk and before milk ejection causes the occurrence of bimodal milk flow curves and often a prolongation of milking time at simultaneously reduced milk flow rates (Bruckmaier and Blum, 1998) resulting in a higher risk of mastitis incidences (Rittershaus et al., 2001).

The effect of tactile stimulation on the milk flow profile is mainly studied at the whole udder level (Bruckmaier and Blum, 1996). However, the most effective study to see the effects of milk ejection reflex on milk flow should be done at a quarter level (Tančin et al., 2003, 2006). Recently we have found a positive relationship between the duration of the decline phase of milk flow and somatic cell counts (Tančin et al., 2002). In the case of bimodal quarter milk flow a longer duration of the decline phase occurred as compared with non-bimodal curves (Tančin et al., 2005). However, there is no detailed study on how premilking stimulation influences the duration of the decline phase. The composition of milk including SCC changes in the course of milking (Bruckmaier et al., 2004). The milk ejection reflex induced before milking by tactile pre-stimulation could also influence the composition of milk in the course of milking. We expect that the pre-stimulation of the udder will improve the distribution of milk constituents during milking, which could be exactly described at a quarter level.

The aim of this study was to investigate the milk flow patterns and the composition of milk in the course of milking with or without pre-stimulation of the udder at a quarter level.

MATERIAL AND METHODS

Sixteen Holstein dairy cows were used in the trial. All cows were in their second lactation and after the peak of milk production (fourth to sixth month). Average milk production was 18 kg on the day of the trial. Measured quarters of dairy cows were free of clinical signs of mastitis. Dairy cows were kept in a loose-housing system and milked twice daily at 05:00 and 16:00. The parameters of machine milking were: 60 cycles/min, 42 kPa, 60:40.

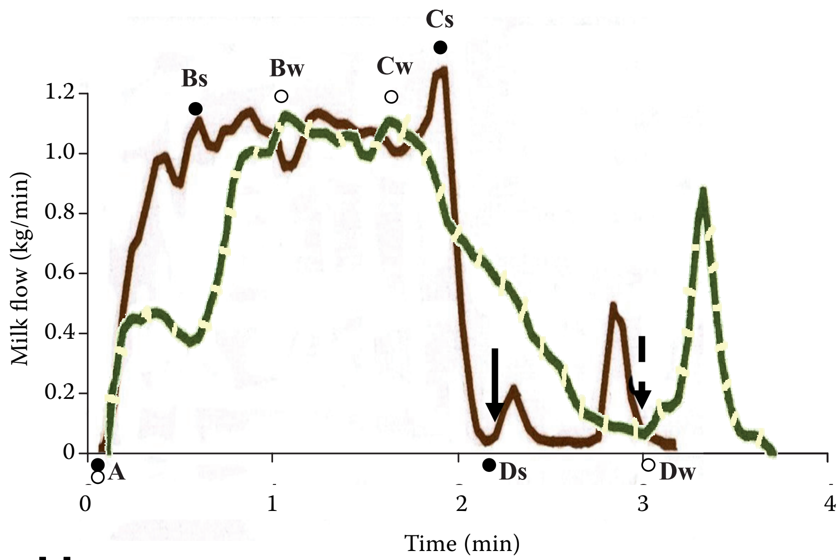
Experimental milking was carried out at the time of routine afternoon milking using a special quarter milking device. One end of the tube was fixed to the teat cup of the attempt-quarter and the other end was fixed to a mobile milk flow recording device (Lactocorder). The outlet of Lactocorder was connected with a tube to the valve having another two outlets. These two outlets were connected and fixed to two lids of small glass cups (0.7 kg). From these two lids other tubes were connected to a second valve. The third outlet of the second valve was connected to the claw of the milking cluster. Thus the vacuum system in the milk line from the liner through Lactocorder and two valves was closed. During milking when one glass cup was filled up (max. 300 ml), the valves were switched to the position at which milk was collected in the second cup. The first cup was removed and a new empty cup was replaced. This procedure was repeated until the milk flow ceased.

During two consecutive evening milkings in a cross-over design two methods of udder preparation were applied to the attempt-quarters. The first treatment (pre-stimulation) consisted of forestripping (removal of 5 ml of milk), 40 s tactile stimulation by hand followed by cleaning with a towel (in total 60 s). The second treatment (no stimulation) was forestripping followed by cleaning with a towel (in total 10 s). Immediately after the udder preparation the four teat cups were attached to the udder. After the milk flow ceased as indicated by the activation of Lactocorder indicator, the valves were switched to obtain milk from machine stripping (MS).

Peak flow rate and yield within 2 min of milking were measured by Lactocorder. The time of milk flow was adapted from the milk flow graphs made by Lactocorder and represented the time between the start of milk flow and the point when the milk flow approached the x-axis. The duration of single milk flow phases is described by Tančin et al. (2006) and in Figure 1.

Milk composition was measured by MILKOSCAN ST 120 and SCC by FOSSOMATIC 90.

Based on the actual quarter milk yield, the obtained fractions were selected and mixed to receive six fractions (P – cisternal milk during the first 30 s of milking without stimulation and the first 300 ml during milking with stimulation, 0–25%, 25–50%,



Milk flow and start of stripping with (s) and without (w) pre-stimulation, respectively points indicate the milk flow phases: AB increase, BC plateau, CD decline

Figure 1. The effect of milking with or without pre-stimulation on the milk flow patterns from the quarter of one cow

50–75%, 75–100%, MS) and five portions (25%, 50%, 75%, 100%, 100% + MS) of removed milk. The fractions P of milking both without and with pre-stimulation are a part of 0–25% fraction. The obtained values were statistically evaluated by the paired *t*-test between two treatments and MIXED model (SAS, 2001) fixed effect of treatment nested within fractions or portions.

RESULTS AND DISCUSSION

Milking with udder pre-stimulation resulted in a numerically but non-significantly higher milk yield (2.85 ± 0.91 kg) and significantly ($P < 0.05$) shorter milking time (3.35 ± 1.09 min) and duration of the increase (42 ± 14 s) and decline phase (15 ± 10 s), lower stripping yield (0.113 ± 0.045 kg), higher peak flow rate (1.04 ± 0.21 kg/min) and milk yield at the 2nd min (1.69 ± 0.36) in comparison with no pre-stimulation milking (2.74 ± 0.89 kg; 4.24 ± 1.75 min; 74 ± 28 s; 38 ± 29 s; 0.170 ± 0.082 kg; 0.93 ± 0.22 kg/min; 1.37 ± 0.40 kg, resp.). Thus the udder pre-stimulation is crucial for the efficiency of milk removal (Bruckmaier and Blum, 1998). This effect is clearer at a quarter level as it is documented as an example of the response of the quarter to milking with or without pre-stimulation (Figure 1). Indirectly from the figures published by Wellnitz et al. (1999) it was possible to see the prolongation of the duration of decline phase at single quarters during milking without pre-stimulation. Milk flows from a quarter with bimodality also had a significantly longer duration of the decline phase as compared with milk flows without bimodality (Tančin et al., 2005). Therefore, this study could be considered as direct evidence that milking without pre-stimulation negatively influences the milk flow not only at the beginning of milking but also at the end of milk flow. The longer duration of the decline phase at a quarter level is connected with significantly higher SCC (Tančin et al., 2002, 2006). The majority of the machine-induced infections occur near the end of milking and a possible explanation could be taken over from Philpot and Nickerson (1991). They discussed the possible importance of reduced milk flow near the end of milking. Reduced milk flow near the end of milking decreases the chance of microorganisms being flushed out of the teat and increases the likelihood of infection in the quarter. The duration of the decline phase at the quarter level should therefore be minimized because of the possible negative relationship to udder health.

The pre-stimulation did not influence the content of milk constituents and SCC in the whole milk yield without (100% portion) or with machine stripping (100% + MS) (Table 1A). Johansson et al. (1998) did not find the effect of pre-stimulation on protein and fat content either. However, they reported the lactose content significantly lower by 0.05% in milk obtained during milking with pre-stimulation. In another study (Gorewit and Gassman, 1985) the effect of the duration of udder pre-stimulation on milk components was not reported.

The content of fat significantly increased in steadily in successive milk portions in the course of milking. There was also a significant increase in dry matter during milking without pre-stimulation (Table 1A). Significant differences were found between milking with no pre-stimulation and with pre-stimulation in fat content at 25% and 50% portions, and both in protein and dry matter at 25% portions (Table 1A). There were more significant differences in the milk compositions between fractions in relation to the udder preparation especially for milking with no pre-stimulation (Table 1B) as compared to portions. There were not any differences in the content of fat at the end of milking at both portions and fractions in relation to udder pre-stimulation methods.

A significant increase in fat content in advanced fractions during milking observed in our study is in agreement with the study of many authors (Waldman et al., 1999; Ayadi et al., 2004; Bruckmaier et al., 2004) pointing out the higher fat content in alveolar milk as compared to cisternal milk. We could not confirm that pre-stimulation positively influenced fat content in the whole milk yield as we expected due to the better emptying of the alveolar space. Though, Brandsma (1978) found that the fat percentage in residual milk was lower in heifers with no pre-stimulation as compared with well prepared cows. In our experiment we measured a numerically lower fat percentage in milk of machine stripping with no pre-stimulation. On the other hand, we could see that the above-mentioned increase of fat during milking was smoother when pre-stimulation was applied.

However, we could demonstrate a lower content of protein in 25% portion or in both fraction P and 25% during milking without pre-stimulation as compared with pre-stimulation. It is probably related to the highest content of protein

Table 1. Milk constituents of removed milk portions (**A**) and fractions (**B**) in relation to milking with or without pre-stimulation

A	Removed portions of milk							
	stimo	25%	50%	75%	100%	100% + MS	Std Error	*F*-test
Fat	without	2.42^{aA}	2.92^{acA}	3.24^{bc}	3.53^{b}	3.61^{b}	0.27	< 0.0001
(g/100 ml)	with	2.94^{aB}	3.23^{abB}	3.39^{b}	3.58^{b}	3.59^{b}		
Protein	without	3.49^{A}	3.51	3.48	3.47	3.46	0.11	0.0017
(g/100 ml)	with	3.56^{B}	3.61	3.58	3.54	3.51		
Lactose	without	5.02	5.14	5.15	5.11	5.09	0.11	0.0378
(g/100 ml)	with	5.13	5.24	5.19	5.09	5.02		
Dry matter	without	11.68^{aA}	12.33^{ab}	12.66^{b}	12.90^{b}	12.96^{b}	0.41	< 0.0001
(g/100 ml)	with	12.36^{B}	12.81	12.87	12.92	12.85		
SCC	without	4.97	4.93	4.93	4.95	4.98	0.17	< 0.0001
(log/ml)	with	4.69	4.66	4.69	4.77	4.81		

B	Single fractions of milk								
	stimo	*P*	0-25%	25–50%	50–75%	75–100%	MS	Std Error	*F*-test
Fat	without	2.32^{aA}	2.42^{abA}	3.41^{abc}	3.89^{b}	4.26^{c}	5.03^{d}	0.35	< 0.0001
(g/100 ml)	with	2.85^{aB}	2.94^{aB}	3.41^{a}	3.73^{a}	4.23^{ab}	5.31^{b}		
Protein	without	3.43^{A}	3.49^{A}	3.53	3.43	3.43	3.33	0.11	< 0.0001
(g/100 ml)	with	3.56^{B}	3.56^{B}	3.56	3.53	3.47	3.39		
Lactose	without	4.85^{a}	5.02^{ab}	5.23^{b}	5.17^{ab}	4.89^{ab}	4.78^{a}	0.27	< 0.0001
(g/100 ml)	with	5.13^{ab}	5.15^{a}	5.15^{ab}	5.07^{ab}	4.89^{ab}	4.74^{b}		
Dry matter	without	11.32^{aA}	11.68^{abA}	12.97^{abc}	13.28^{b}	13.61^{c}	14.11^{c}	0.44	< 0.0001
(g/100 ml)	with	12.25^{aB}	12.36^{aB}	12.83^{ab}	13.05^{ab}	13.37^{ab}	14.12^{b}		
SCC	without	5.12	4.97	4.72	4.88	4.99	5.07	0.18	< 0.0001
(log/ml)	with	4.75	4.69	4.64	4.77	4.91	5.08		

^{a,b,c}Means within the row and ^{A,B}means within the column of components with different letters are significantly different ($P < 0.05$)
MS = Machine stripping
stimo – stimulation, milking with stimulation represented 60 s of udder preparation before the cluster attachment to the udder and without stimulation represented 10 s of udder preparation only

in the first 25% alveolar fraction (Waldmann et al., 1999; Ontsouka et al., 2003; Sarikaya et al., 2005) causing a higher percentage of protein at the beginning of milking with pre-stimulation (milk ejection) as compared with milking without stimulation (delayed milk ejection). On the other hand, Bruckmaier et al. (2004) did not report the effect of fractions on lactose, protein and SCC in healthy quarters either, but the tendencies of component changes of our results were similar. The changes of SCC in milk between forestripping and alveolar fraction are more visible if the health status of the quarter is considered (Sarikaya and Bruckmaier, 2006).

In conclusion, pre-stimulation positively influences the parameters of milk flow and therefore the efficiency of milk removal. There were not any differences in the content of milk constituents in the whole milk yield with or without MS between long and short udder preparation. However, pre-stimulation contributed to better distribution of constituents in milk fractions during milking.

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