OVERMILKING AND TEAT CONDITION

Morten Dam Rasmussen
Danish Institute of Agricultural Sciences
Tjele, Denmark

Introduction

Overmilking is a matter of concern because it may affect teat condition and udder health. The historic background for overmilking is mainly based on the assumption that all milk should be removed from the udder in order to maximise the milk yield. However, breeding for high milk yields has provided cows with a high alveolar capacity, large cistern capacity, and a higher proportion of cisternal to alveolar capacity. The high percentage of cisternal capacity makes cows more efficient as milk producers and less sensible to changes in milking routines and emptying of the udder because the feedback inhibitor is active in alveolar milk only. An overall selection of cows with high milk yields and a relatively high percentage of cisternal capacity may also explain why cows increased their milk yield with good pre-stimulation 30 years ago but not today. Consequently, we may also expect less influence of milk left as strip yield on milk production in modern high-producing dairy cows. Today, there is really no benefit of overmilking since overmilking increases the machine-on time and decreases the capacity of the milking parlor. This paper will focus on the effects of overmilking on teat condition and give suggestions of how to avoid it. A main part of the paper will concern threshold settings for automatic detachment of the milking unit.

When Does Overmilking Start and What Happens Inside the Teat?

Overmilking starts when the milk flow to the teat cistern is less than the flow out of the teat canal. Measurements within the teat cistern show that it takes as few as 10 pulsations from emptying of the quarter until the vacuum in the teat cistern follows the pulsation curve. There is no vacuum or only a small overpressure in the teat cistern during the collapsed phase of the liner. The vacuum within the teat cistern may reach values up to about 90% of the teat end vacuum during the open phase of the liner. Similar patterns can be seen when measuring mouthpiece chamber vacuum (Rasmussen et al., 1994). Mouthpiece chamber vacuum normally increases during overmilking and fluctuations become larger. If the vacuum in the teat cistern is higher than beneath the teat end for short periods of time, these reverse pressure gradients across the teat canal may give rise to bacterial invasion of the teat cistern. Reverse pressure gradients occur only during milking of empty teats (Rasmussen et al., 1994) and overmilking will therefore increase the possibility of bacteria entering the teat by this method. The influence of overmilking on udder health has been evaluated at several occasions. Natzke (1978) concluded that if overmilking is associated with mastitis, its effects appear to be small. On an average, front teats will start overmilking at a threshold value of about 400 g/min and rear teats at about 200 g/min. The general overmilking of front teats does not result in a poorer udder health.

How Is a Correct Endpoint Assessed?

Traditionally, a cow has been considered sufficiently milked when the milk flow rate drops below 200 g/min. Initiation of detachment at a milk flow rate of (e.g.) 200 g/min does not ensure that the milk flow rate is 200 g/min when the milking unit is detached. Apart from the switch point, the actual flow rate at removal of the milking unit depends on the final delay time and the rate of decrease in milk flow towards the end of milking. A long final delay time will cause overmilking of cows with a rapid decrease in flow rate at the end of milking. Conversely, the actual milk flow rate at removal of the milking unit will be less influenced by the final delay time for cows with a slow flow rate decrease. Berre (1990) tested different automatic cluster removers (ACRs) and found a difference in machine-on time of 1.5 min between a flow rate decrease of 0.15 and 0.60 kg/min^2. Berre (1990) concluded that there was no relationship between chosen switch points of ACRs and time of removal of the milking unit. Consequently, the switch point indicates the highest milk flow rate that would initiate removal of the milking unit.

We do not have an ISO-standard test procedure for ACRs that will give the correct switch points and delay times or formulas applying to specific set-ups. Some of the difficulties that interfere with tests are: measuring technique, measuring point in respect of ACR sensors, milk or artificial test fluid, length of hoses, lifting height, and pulsating or continuous flow. Stated threshold values of different types of ACRs differ often and the threshold of 300 g/min for one type of ACR is not necessarily the same as 300 g/min for another type. Delay time is probably the most variable factor among types of ACR because systems vary from electronic measurements, counts of slugs, to mechanical devices. A 10-s delay time for one type of ACR may equal 2 s for another type. Consequently, changes in switch points and delay times have to be evaluated within farm. Determining the start of overmilking can only truly be performed when measuring the flow from individual quarters and very close to the teat end. Measurement of mouthpiece vacuum is a sound method to define end point of milking for the individual quarters.

What Happens to the Teat Condition?

The “Teat Club International” suggested a range of teat condition scores for the evaluation of field data and divided them into short- (single milkings), medium- (few days or weeks), and long-term effects (several weeks) (see Neijenhuis et al., 2004 these procedings). For field evaluations, the most important short-term scores in relation to overmilking are the effects on teat colour and ringing at the base of the teat and the most important long-term effect is hyperkeratosis.

Hillerton et al. (2000) did a survey on teat condition in 20 different newly installed milking parlours. One group was classified as a common (modern) type and the second type as a traditional type with heavy clusters and wide bore tapered liners. The more common type of cluster was always associated with better teat condition including teat colour, firmness, thickening at the base of the teat, and openness of the orifice. These differences were assigned to differences in cluster weight, overmilking, applied vacuum, and design of the liner. Type of liner and overmilking were the objects of a study comparing three different liners, automatic detachment at 200 g/min, or overmilking for 2 or 5 min (Hillerton et al., 2002). About one third of the teats were visibly redder at the automatic detachment than before milking (Table 1). This

frequency increased considerably with overmilking but was independent of liner type. Ringing at the base of the teat was evident for all liners at automatic detachment and the proportion of teats with palpable rings increased with overmilking. Firmness was infrequent on teats milked with liner 1 but evident and considerable when milking and overmilking with liners 2 and 3. The authors concluded that liner 1 was the most suitable liner for this herd whereas the wide bore liner 2 and narrower bore liner 3 scored worse on teat condition and especially with overmilking. It appears that as the vacuum level increases and the massage provided to teats during milking decreases, the negative effects of overmilking become more pronounced. Lack of massage may be due to the selection of a wrong liner for that size of teats, stiff liners, or pulsation failure.

Table 1. Number of teats scored as normal or abnormal for colour, ringing, and touch when milking with three different liners and three degrees of overmilking (Hillerton et al., 2002).

Liner	**1**			**2**			**3**		
Overmilking, min	0	2	5	0	2	5	0	2	5
Colour									
Normal	16	12	6	18	4	2	18	8	8
Discoloured	8	12	18	6	20	22	6	16	16
Ringing									
None	4	4	0	2	3	2	2	1	0
Visible	10	6	2	4	3	0	8	7	2
Palpable	10	14	22	18	18	22	14	16	22
Touch									
Normal	24	24	19	16	4	4	16	4	0
Firm or hard	0	0	5	8	20	20	8	20	24

How Can We Avoid Overmilking?

Early detachment can improve teat condition without loss of milk

There are very few reports on the influence of ACRs on milking performance and udder health and only one in a reviewed journal. Sagi (1978) tested threshold values of 200 and 400 g/min in a change-over experiment with 16 cows. The threshold value of 400 g/min compared with 200 g/min reduced the machine-on time by 0.68 min per day and had no significant influence on milk yield, but increased the amount of milk that could be milked out after removal of the automatic cluster. Long-term studies are needed in order to evaluate the influence on udder health.

Rasmussen (1993) reports on an experiment with 135 freshly calved cows that were split into two treatments: Group 200 was milked with ACRs with a switch point of 200 g/min and a delay time of 18 s; Group 400 was milked with ACRs with a switch point of 400 g/min and a delay time of 12 s. Treatments started 4 days after calving and lasted 36 weeks for first lactation cows and 12 weeks for older cows. The cows were milked in stanchion barns with high pipeline milking. Main results of the experiment can be seen in Table 2.

Table 2. Milking performance and udder health of cows with automatic cluster removers detached after threshold values of 200 or 400 g/min (Rasmussen, 1993).

	First lactation		Older cows	
Group	200	400	200	400
No. of cows	38	33	32	32
Machine-on time, min	5.54*	5.01	7.90*	7.39
Energy corr. milk, kg	22.78	22.73	33.26	33.44
Teat end eversions, %	39*	25	67*	54
Teat thickness front, %	3.4	2.3	0.7	2.7
Teat thickness rear, %	5.5*	1.1	-0.8	-0.1
Cell count, log	4.94	4.84	5.11	5.02
Clinical mastitis per 100 cow, days	0.17	0.25	0.75	0.25
Cows subclinically infected, %	37.0	45.7	40.3	39.1
Cows subclinically newly inf., %	16.4	15.3	15.0	14.8

* Significantly different from value of Group 400: $P < 0.05$.

Overall machine-on time was reduced by 0.52 min ($P < 0.05$) by increasing the threshold from 200 to 400 g/min. The reduction in machine-on time seemed to be consistent throughout the lactation. Peak milk flow rate was not increased and the average milk flow rate of Group 400 cows was slightly higher than that of Group 200 cows. Milk yield and treatment group did not influence milk composition. Hindquarters normally have higher milk yield and take longer time to milk than forequarters; consequently, the reduction in machine-on time of Group 400 could have reduced the proportion of milk in hindquarters, but no such change was detected.

Significant differences in the scores for teat end eversion in older cows were established after only 4 weeks of milking and after 8 weeks of milking in first lactation cows. These differences between treatment groups clearly demonstrate that the last 0.5 min of milking when teats are getting empty of milk is a sensitive period for developing hyperkeratosis or teat end eversions. Teat end thickness increased during milking for hindteats of first lactation cows in Group 200 compared with Group 400. The same trend was observed in foreteats, but there was no significant difference in the teat end thickness of older cows, although the trend seemed to be reversed. There was no difference in cell counts between the two groups. There was no difference between groups in the number of clinical cases of mastitis in first lactation cows or in the subclinical udder health status of the cows. The older cows of Group 200 developed more clinical cases than Group 400 but this difference was not significant. The percentage of quarters subclinically infected during lactation were 7.4 and 9.5% and the new infection rates 4.2 and 5.8% in Group 200 and Group 400, respectively, for cows not having subclinical or clinical infections during the first 10 days after calving. These differences were not significant. Those cows that had an infection in the early stage of lactation had 23.1 and 23.5% infected quarters compared with new infection rates of 11.7 and 7.2 % ($P < 0.05$) in Groups 200 and 400, respectively. Rasmussen (1993) concludes that the milking unit can be detached at a milk flow rate of 400 g/min instead of 200 g/min without having a negative influence on milk yield. Machine-on time is shortened and teat condition improved, and udder health does not seem to be affected.

Even higher thresholds may be used without loss of milk. Stewart et al. (2002) compared detachment thresholds of 0.50 with 0.64 kg/min in one herd and 0.73 with 0.82 kg/min in four herds. The higher thresholds increased milk flow, decreased machine-on time, increased milk yield in two herds, and had no effect in the remaining three herds. Teat condition was not scored in this experiment but there is no reason to believe that teat condition should be poorer with the more aggressive take-off.

Quarter detachment

Individual quarter take-off is used for automatic but not for conventional milking. The benefit should be that milking can be done faster at a higher vacuum without harming the teat condition. So far, results have not been truly convincing which may be explained by low threshold settings for detachment, measurement of flow up to 2 m from the teat end, and poor let-down and low flow rates with more frequent milking. Moreover, interactions with liner type, pulsator settings, and vacuum may play a significant role. Oxytocin is released even though milking is only performed on one teat and detachment of one quarter will not influence the oxytocin profile. Detachment thresholds for individual quarters should be about 50% of that used for the udder level and not 25% since detachment at the udder level is normally initiated when the first two quarters are done. However, the place of measurement probably matters more than the exact threshold. An interesting concept is to detach at a certain percentage of the peak flow, which enables the system to cope with high and low flow rate cows and quarters within a herd. The calf uses individual quarter milking and take-off and applies heavy overmilking if allowed and at a very fluctuating and high vacuum (Rasmussen and Mayntz, 1998). Obviously, the teats are built for such a rough treatment, but probably only when pauses with no vacuum or pressure are applied throughout the suckling period.

Premilking teat preparation

High values of detachment thresholds are only practicable if the milk flows continuously shortly after attachment. Consequently, cows must be pre-stimulated and milk ejection evoked before attachment of the milking unit. Oxytocin is released as long as milking continues and causes no discomfort to the cow. In terms of milk yield at twice daily milking, pre-stimulation may be responsible for less than 5% whereas the release of oxytocin during milking may extract more than 95%. A sufficient premilking teat preparation is recognised by no bimodal milk flow at the beginning of milking. Bimodal flow means that cisternal milk is milked out before alveolar milk is ejected to the cisterns resulting in a period with “empty” milking. Lack of preparation increases the machine-on time and may influence teat condition negatively. Vacuum in the teat cisterns will follow the pulsations (Rasmussen et al., 1994) and be a risk of reverse pressure gradients across the teat canal. Both lack of stimulation and mal function of the ACR can easily be detected on milk flow curves (Wallace et al., 2003).

The Trend Is Higher Vacuum, Higher Flow, and Aggressive Detachment

There is a general trend to increase the milking speed in order to improve the capacity of the milking parlour or automatic milking system. Saving just 5 s per cow in an automatic milking system will make it possible to milk one more cow per milking unit per day. Improvement of the capacity in milking parlours does not depend solely on the machine-on time, but field experience certainly proves that more cows can be milked better with an aggressive detachment i.e.

detachment at a high flow rate level. Reid and Stewart (1997) report on two farms with 3 daily milkings where the threshold of ACRs was increased. Herd 1 milked 430 cows in a 2x12 herringbone parlour. The switch point was increased from 300 to 450 g/min and the delay time decreased from 12 to 7 s. The machine-on time decreased from 7.8 to 6.4 min and the milk production increased slightly from 39 to 40 kg per cow per day. Managers of the herd claim that they could easily milk at least 70 more cows with the same labour cost and new settings of ACRs. Herd 2 milked more than 700 cows in a 2x10 herringbone parlour. The switch point was increased stepwise from 200 to 900 g/min and the delay time decreased from 15 to 3 s. The machine-on time decreased from 7.4 to 6.2 min and the milk production increased from 34 to 37 kg per cow per day. A random sample of fresh and mid- to late-lactation cows showed less than 100 g of milk left after detachment in all four quarters. Both dairies reported of less stepping and kicking and especially of first lactation cows after the earlier detachments.

These American field reports show successful application of early detachment of the milking unit for cows milked three times daily. The reported increases in milk yield are probably confounded with a change in other factors as well but show that the potential is there to harvest the milk in less time. Although the machine-on time still decreased with even very high detachment thresholds, these improvements did not affect parlor turns per hour positively (Stewart et al., 2002).

Recommendations

Overmilking may easily be determined by observing some of the following parameters: teat colour and ringing at the base of the teat after detachment, restless or kicking cows during the late flow rate period, nervous first lactation cows, or long milk hoses or claws without milk. If these conditions are observed then increase threshold values and/or decrease delay time of the ACR in small steps. Position the claw well and adjust the load on the four teats, and use a consistent milking routine with respect to each individual cow. First lactation cows are making the future, not the two old cows that are having problems with fully emptying the udder. Watch cows with chronic udder infections. Monitor milk yield and strip yield. Strip yields of 100 ml per cow do not cause a milk yield decrease, but the proportion of cows with more than 250 ml of strip yield should not be above 10%.

It takes longer to milk out the last kg of milk if premilking teat preparation is conducted less efficiently or even omitted. Consequently, a good premilking teat preparation, a short, consistent interval until attachment, and calm cows are prerequisites for detachment at high flow rates. Cows will respond with short machine-on times, excellent teat condition, and proper milk-out.

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