Aspects on quarter milking in automated milking systems

K. Svennersten-Sjaunja[1], I. Berglund[1], G. Pettersson[1] & K. Östensson[2]

[1]Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, (SLU), Kungsängens' Research Centre, S-753 23 Uppsala, Sweden

[2]Department of Clinical Sciences, Box 7039, S-750 07 Uppsala Sweden
E-mail: kerstin.svennersten@huv.slu.se

Summary

The bovine udder consists of four separate quarters, with equal milk yield and milk composition in front and rear quarters, which leads to the conclusion that quarter milking (Q-m) ought to be optimal for the cows. In a series of experiments, Q-m was tested and it was found that Q-m gave better teat condition, higher milk flow and shorter milking time compared to conventional milking. Furthermore, it was observed that Q-m could be used as a diagnostic tool for detecting affected udder quarters. Deviating milk composition, mainly lactose content, indicated quarters with udder disturbances.

Key words: *Quarter milking, milking characteristic, SCC, lactose*

Introduction

Whether quarter milking (Q-m) is a beneficial milking concept has been discussed and during the past decade Q-m was made possible with the introduction of automated milking (AM) systems to the market. The difference between conventional and Q-m is the detachment of the teat cups from the udder. In conventional milking systems the teat cups are attached and detached simultaneously, manually or automatically. With Q-m the teat cups are detached individually, i. e. when the separate udder quarter is emptied or when the milk flow has reached a predetermined level for take off.

There are biological reasons for practicing Q-m. The udder consists of four separate quarters. Under normal circumstances milk that is produced in one quarter never passes over to the other quarters. The distribution of milk yield is, in general, 40 % and 60 % in the front and rear quarters, respectively. The protein and lactose content is almost equal in front and rear quarters while the fat content is higher in front quarters (Table 1). In conventional milking, the uneven distribution of milk yield results in

a shorter milking time for the front quarters compared to the rear ones, which can cause over–milking of the front quarters. Since the milk composition is the same for the front and rear quarters, deviations in composition could be used as a diagnostic tool to detect udder quarters with disturbances caused by bacterial infection or some kind of trauma. At our department, a series of studies have been initiated to evaluate if Q-m is preferable to conventional whole-udder milking, and if deviations in comparative milk composition can be used as a diagnostic tool.

Table 1. Somatic cell count (SCC), milk production gram/hour, fat-, protein- and lactose content in different udder quarters when SCC is below 100 000 cells/ml milk. 22 cows. (LS means ±SE).

	SCC (x 1000 cells/ml)[1]	Milk prod. (gram/h)	Fat (%)	Protein (%)	Lactose (%)
RR[2]	18	388±52	4.63±0.63	3.33±0.09	4.95±0.06
LR	14	399±44	4.60±0.67	3.33±0.12	4.95±0.07
RF	18	265±28	4.85±0.67	3.33±0.11	4.91±0.07
LF	16	265±29	4.81±0.62	3.33±0.09	4.91±0.07

[1]Antilogarithmical value, [2] RR=right rear, LR=left rear, RF=right front, LF=left front. (Berglund et al., 2004b).

Q-m and its effects on milking characteristics and milk somatic cell count (SCC)

The aim with the first study was to test whether there were differences in milking characteristics between Q-m and conventional milking when the cows were milked in a conventional parlour (Seeman, 1997). The study included 14 cows and was carried out at Hamra Farm, DeLaval, Tumba, Sweden. It was a change-over design with two treatments and three periods, where the third period was designed to test for carry-over effects.

Milking characteristics such as milking time and milk flow were positively influenced by Q-m (Table 2). The change in teat-end thickness before and after milking was –2 % and +3.8 % for Q-m and conventional milking, respectively. These results indicated that the Q-m improved the milking procedure.

Since AM enables Q-m, a study was done in order to compare conventional milking in a herringbone parlour with Q-m in an AM system. The 25-week study was divided into three periods, and included 66 cows, which were allotted in two groups of comparable pairs, matched on the basis of milk yield, milk somatic cell count (SCC) and lactation stage before assigning them to either Q-m in the AM system or conventional parlour milking (Berglund et al., 2002).

Table 2. Comparison between quarter milking and conventional milking. 14 cows. (LS means).

	Quarter milking	Conventional milking	Sign Level[1]
Time to milk flow (min)	0.19	0.22	*
Milking time (min)	5.34	5.42	**
Peak flow (kg/min)	3.96	3.82	**
Average flow (kg/min)	2.64	2.55	**

[1]Statistically significant differences between treatments *=p<0.05, **=p<0.01 (Seeman, 1997)

That teat-end thickness was reduced with Q-m, especially in the front teats, compared to conventional milking was observed also in this study (Berglund et al., 2002). Furthermore, the SCC was lower in strip-quarter milk in cows exposed to Q-m compared to conventional milking (Table 3). This effect was however not detected in composite milk.

Table 3. Log SCC in quarter-strip milk milked in AM quarter milking or by conventional parlour milking. 66 cows (LS means)

Period	AM quarter milking	Conventional milking	Sign level
I	3.84^{a} (46)	4.02^{a} (56)	ns
II	3.89^{a} (49)	4.17^{b} (65)	*
III	4.11^{b} (61)	4.84^{c} (126)	***

The anti-logarithmic geometric means are shown within brackets (x 1000 cells/ml). Significant difference *=p<0.05, ***=p<0.001.
[abc] Means within column with different superscripts differ significantly p<0.05. (Berglund et al., 2002)

Quarter milking – a diagnostic tool?

The farmer is informed monthly about individual cow's composite milk SCC content from the official milk recording scheme and the dairy provides analytical results regarding SCC in the tank milk. The farmers base management decisions on these figures. However, a more efficient way for detection of udder disturbances would be to analyse the milk at each separate udder quarter, whereby the dilution effect from healthy quarters is prevented. Indeed in our studies we have observed that in as much as 12 % of the composite milk samples with SCC below 200 000 cells/ml contained one or more udder quarters with CMT 3 and above (Berglund et al., 2004a). Those results indicate the importance of udder quarter sampling. When evaluating mastitis detection with an electronic nose it was also observed that the measurements must be taken at udder quarter level (Eriksson et al., 2005).

Milk composition is the same in healthy quarters but is altered in disturbed quarters, thus deviations in milk composition at the udder-quarter level could be used as a diagnostic tool. In order to further test this hypothesis a 13-week long study was initiated that included 68 cows. In total 4158

quarter-milk samples were analysed (Berglund et al., 2004b). Depending on the obtained milk SCC results the cows were divided in three groups; a) cows with all four quarters below 100 000 cells/ml, b) cows with moderately increased SCC in one udder quarter (> 100 000 cells/ml and > 1.5-fold higher than the opposite quarter) at one occasion, and c) cows with moderately increased SCC in one quarter at more than one occasion. Composition differences within pairs of udder quarters (unaffected – affected) were calculated and tested if the difference was separated from 0.

In b group cows only lactose content differed significantly ($p<0.05$) following increased SCC. In group c the fat and protein content also deviated significantly (Table 4). The results indicated that deviations in milk composition can be used as a tool for detection of udder disturbances and lactose seems to be a promising indicator.

Table 4. Milk composition (fat, protein and lactose content (%)) in affected (A) and unaffected (N) udder quarter when SCC increased at more than one sampling occasion. 12 cows (LS means).

	Sampling occasion[1]					
Variable	-3	-2	-1	0	+1	+2
Fat (%)						
N	4.69	5.39	4.95	4.92	5.27	5.01
A	4.80	5.34	4.95	4.75	5.23	4.94
Diff N-A	.10	.01	.03	.20	.08	.07
Sign level	ns	ns	ns	*	ns	ns
Protein (%)						
N	3.41	3.44	3.37	3.37	3.4	3.32
A	3.41	3.42	3.33	3.43	3.43	3.33
Diff N-A	.01	.02	.05	-.06	-.04	-.03
Sign level	ns	ns	*	***	(*)	ns
Lactose						
N	4.87	4.86	4.88	4.86	4.87	4.89
A	4.81	4.83	4.86	4.69	4.73	4.71
Diff N-A	.05	.02	.04	.17	.14	.17
Sign level	ns	ns	ns	***	***	***

[1] Sampling occasion –3 = 10 or 11 days before sampling occasion 0; - 2 = 7 days before 0; - 1 = 3 or 4 days before 0. +1 = 3 or 4 days after 0; +2 = 7 days after 0. 0 = sampling occasion when milk SCC was elevated.

[2] ns=not statistically significant, * $p<0.05$; ** $p<0.01$; *** $p<0.001$ (Berglund et al 2004b)

Further applications with Q-m

Since we observed that quarters with a moderate increase in SCC influenced milk composition it can be questioned if it is worthwhile to separate milk from quarters with elevated SCC. In a study where the protein composition in relation to SCC was studied, we found that both the casein content and casein number were significantly decreased in affected quarters (Table 5) (Åkerstedt, 2003). Whether or not this will be of importance for the dairy industry as such has to be further evaluated.

Table 5. Protein, casein, whey, casein number and lactose (%) in udder quarter with low SCC and adjacent udder quarter with elevated SCC. 36 cows.

	Low SCC mean	High SCC mean	Diff mean	Sign level[1]
Protein (%)	3.54	3.58	0.04	ns
Casein (%)	2.68	2.64	-0.04	*
Weigh (%)	0.86	0.94	0.08	***
Casein no. (%)	76	74	-2	***
Lactose (%)	4.8	4.59	-0.21	***

(Åkerstedt, 2003) [1]ns=not statistically significant, * $p<0.05$; ***$p<0.001$

It can be concluded that there are benefits with quarter milking. It improves the milking procedure and it can be used as a diagnostic tool. However, it has to be mentioned that individual treatment of quarters, giving different types/degree of teat stimulation during milking can influence the milk synthesis (Svennersten et al., 1990). In a fully automated milking system provided with Q-m there are many possibilities for improving the milking procedure. The physiological possibilities and applications exist – we just need to learn how to take advantage of the potential opportunities with Q-m.

References

Berglund, I., Pettersson, G. & Svennersten-Sjaunja, K., 2002: Automatic milking: effects on somatic cell count and teat end-quality. Livestock Prod. Sci. 78:115-124.

Berglund, G., Pettersson, G., Östensson, K. & Svennersten-Sjaunja, K., 2004a: Frequency of individual udder quarters with elevated CMT scores in cow milk samples with low somatic cell counts. Vet. Rec., 155 (7):213.

Berglund, G., Pettersson, G., Östensson, K. & Svennersten-Sjaunja, K., 2004: Quarter milking – a possibility for detection of udder quarters with elevated SCC. In: Eds Meijering, A., Hogeveen, H. & de Koning, C.J.A.M. Proceeding of the international symposium Automatic milking – a better understanding. Lelystadt, Holland.

Eriksson Å., Persson Waller K., Svennersten-Sjaunja K., Haugen J-E., Lundby F. & Lind O., 2005: Detection of mastitic milk using a gas-sensor array system (electronic nose). Int. Dairy J. In Press.

Seeman, A., 1997: Comparative study between quarter milking and conventional milking according to milk production, milk flow, machine on time and teat treatment. Sw. Univ. of Agric. Sciences, Dep. of Animal Nutr. and Managem. Examensarbete 90, 39 pp (In Swedish).

Svennersten, K., Claesson, C-O., & Nelson, L., 1990: Effect of local stimulation of one udder quarter on milk production and milk components. J. Dairy Sci. 73:970-974.

Åkerstedt, M., 2003: Does milk protein composition in separate quarters change during high somatic cell count (SCC)? Sw. Univ. of Agric. Sciences, Dep. of Anim. Nutr. and Managem.Examensarbete 181, 36 pp. (In Swedish).