*Journal of Animal and Feed Sciences, 16, Suppl. 1, 2007, 151–155*

# Effect of frequent milking on milk fat and protein*

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ABSTRACT

The effects of frequent milking on milk quality were studied in a unilateral, short-term milking experiment. In period one, 11 cows were milked on each udder half twice daily; in period two one udder half was milked twice daily while the contralateral was milked four times daily. In the more frequently milked udder half the milk yield, FFA content and average fat globule size increased. No effect was observed on fat content, fatty acid composition and γ-glutamyl transpeptidase. The plasmin activity decreased but no proteolytic degradation of milk proteins was observed. Concentration of Na decreased while K increased.

KEY WORDS: milking frequency, fat, FFA, fat globule, protein, plasmin

## INTRODUCTION

Increased milking frequency (MF) has been reported to increase the milk yield and decrease milk fat and protein content in several studies (Erdman and Varner, 1995; Klei et al., 1997), whereas in other studies no change in composition has been observed (Amos et al., 1985; Svennersten-Sjaunja et al., 2002). The effect of increased MF on the raw milk quality has been reported more consistently. Undesirable effects on milk fat, such as increased content of free fatty acids (FFA) have been reported (Klei et al., 1997; Svennersten-Sjaunja et al., 2002), which can increase the risk for off-flavour in the milk. More desirable effects for milk protein, such as lower activity of the enzyme plasmin, have been observed (Sorensson et al.,

* Supported by the Swedish Farmers Association (SLF) and Danish Dairy Research Foundation
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2001). Plasmin causes degradation of β-casein to γ-casein and proteose-peptone, which influence the quality of milk for cheese production (Bastian, 1996).

The mechanism behind these effects is not fully evaluated. Both technical and biological reasons have been proposed to explain the affects on milk fat. Increased air exposure during milking which can damage the fat globules could be one reason. Raised enzymatic activity of fatty acid synthetase and acetyl CoA carboxylase, responsible for the *de novo* synthesis of milk fat, and thereby a higher proportion of short-chained fatty acids in the milk, is another suggestion (Klei et al., 1997). The nutritional status, along with MF, can influences milk FFA content (Svennersten-Sjaunja et al., 2002). For protein, increased MF shortens the time in which milk is stored in the udder, whereby proteolytic enzymes such as plasmin, have less time to degrade the milk proteins (Sorensson et al., 2001). Lower plasmin activity due to increased MF could be a result of improved integrity of the tight junctions between the milk secreting cells in the udder because of less udder pressure.

The aim of the present study was to evaluate the effects of increased MF when the effects of environment and nutrition were eliminated and mainly udder related effects on milk synthesis were considered. The hypothesis was that there is no difference between udder halves (UH) when they are milked with the same frequency but when MF is increased in one UH both yield and composition will be affected in that specific UH. The present report is a summary of Wiking et al. (2006) and Svennersten-Sjaunja et al. (2006).

## MATERIAL AND METHODS

The study was carried out at Kungsängens Research Centre, Swedish University of Agricultural Sciences (Uppsala). Eleven cows of the Swedish Red breed in lactation number 1-4 and lactation week 8-50 participated in the study. The average milk somatic cell count (SCC) before the initiation of the experiment was below 100 000 cells/mL milk in the cow composite milk. Quarter strip milk samples were analysed for SCC during the experiment.

The study lasted for 12 days with two five-day long periods. In the first period, the cows were milked on each UH twice daily at 12-h intervals; in the second period they were milked twice daily on one UH and four times daily at 6-h intervals on the contralateral UH.

Milk yield was registered at every milking. Milk samples were taken from both UH. FFA was analysed in both fresh milk and milk cold stored for 24 h. The other milk samples were analysed in fresh milk only. Samples were analysed for content of fat, protein and lactose by Mid Infrared photospectroscopy (MilkoScan FT120 FOSS Electric, Denmark). For analysis of FFA, fatty acid composition, fat globule size and activity of γ-glutamyl transpeptidase (see Wiking et al.,

2006). Casein content was determined by the rennet method (Arla Food analytical directions 30:004, 001210), plasmin, plasminogen-derived activity and degree of proteolysis were determined as described by Wiking et al. (2002) and Larsen et al. (2004). Content of Na and K ions was determined by flame photometry (Flame Photometer FF-IL 943, Instrumentation Laboratory Milan, Italy) and SCC was analysed by electronic fluorescence based cell counting (Fossomatic 5000, Foss Electric, Denmark). Paired t-test was used to evaluate effects of increased unilateral milking frequency.

## RESULTS AND DISCUSSION

The SCC in the quarter strip milk yield was 116 000 cells/mL (range 11 000-569 000) on average. The udder health was judged as good since SCC is higher in strip milk compared to SCC in composite milk samples (Östensson et al., 1988). No differences between the two UH in milk yield and composition were observed in period one verifying that the proposed hypothesis could be used.

The milk yield was 4.5% higher in the more frequently UH. No or only minor difference between the UH in period two were observed for the content of milk fat, protein and lactose (Table 1).

Table 1. Milk yield (kg), fat, protein and lactose content (%) in udder halves (UH) milked twice daily in period one and one UH was milked twice daily while the contralateral was milked four times in period two. Results are expressed as mean and standard deviation (SD); n=11

| | Period 1 (control period) milking frequency | | Diff[1] | Period 2 (experimental period) milking frequency | | Diff |
|---|---|---|---|---|---|---|
| | 2 x | 2 x | | 2 x | 4 x | |
| Milk yield | 14.32 (4.45) | 14.20 (3.95) | 0.11 (0.84) | 14.77 (5.26) | 15.42 (4.76) | -0.65 (1.43)*[2] |
| Fat | 4.56 (0.67) | 4.57 (0.58) | -0.01(0.17) | 4.71 (0.70) | 4.59 (0.68) | 0.12 (0.28) |
| Protein | 3.70 (0.58) | 3.69 (0.56) | 0.01 (0.04) | 3.56 (0.58) | 3.53 (0.55) | -0.02 (0.05) |
| Lactose | 4.51 (0.21) | 4.52 (0.18) | -0.01 (0.04) | 4.47 (0.21) | 4.49 (0.18) | -0.02 (0.05) |

[1] Diff - difference between the two udder halves

[2] * - statistical significant difference $P<0.05$

Increased MF raised the content of FFA in the cold stored milk (Table 2), but no effect was seen in the fresh milk. The volume based average fat globule size was significantly ($P<0.01$) larger in the milk collected from the UH milked four times daily (4.36 μm) compared to the UH milked two times (4.28 μm). Neither short nor long-chained fatty acids were affected. No change was observed in the activity of γ-glutamyl transpeptidase (Wiking et al., 2006). The results indicate that the increased FFA can be due to the larger fat globules, since it has been

observed that larger fat globules are more unstable than smaller globules (Wiking et al., 2003).

Table 2. FFA content (meqv./100 g fat) in milk from udder halves (UH) milked twice daily in period one and one UH was milked twice daily while the contralateral was milked four times in period two. Milk samples were stored cold (5°C) during 24 h, a.m. and p.m. milkings. Results are expressed as mean and standard deviation (SD); n=11

| | Period 1 (control period) milking frequency | | Diff[1] | Period 2 (experimental period) milking frequency | | Diff |
|---|---|---|---|---|---|---|
| | 2 x | 2 x | | 2 x | 4 x | |
| FFA a.m. | 1.22 (0.58) | 1.14 (0.41) | 0.08 (0.19) | 1.14 (0.46) | 1.44 (0.68) | -0.30(0.24)**[2] |
| FFA p.m. | 1.62 (0.62) | 1.33 (0.68) | 0.29 (0.98) | 1.14 (0.42) | 1.55 (0.77) | -0.41 (0.41)** |

[1] Diff - difference between the two udder halves

[2] **- statistical significant difference P<0.01

Casein content was not affected by MF neither at a.m. (2.65%) or p.m. milking (2.75%). In the milk collected during a.m. the plasminogen-derived activity decreased (P<0.01) from 99 to 83 (dA405/min/mL milk). Plasmin activity decreased both during a.m. and p.m. milking (Table 3). The results indicate that increased MF may influence protein quality. In this study no effect was detected on casein content, probably since fresh milk was analysed. It cannot be excluded that the effect of increased plasmin activity would have been detected in milk stored for more than 24 h. No significant effect was observed for proteolysis.

Table 3. Plasmin activity (dA405/min/mL milk) in udder halves (UH) milked twice daily in period one and one UH milked twice daily while the contralateral was milked four times in period two, a.m. and p.m. milkings. Results are expressed as mean and standard deviation (SD); n=11

| | Period 1 (control period) milking frequency | | Diff[1] | Period 2 (experimental period) milking frequency | | Diff |
|---|---|---|---|---|---|---|
| | 2 x | 2 x | | 2 x | 4 x | |
| Plasmin a.m. | 102 (42) | 95 (32) | 8 (18) | 103 (34) | 82 (28) | 21 (12)***[2] |
| Plasmin p.m. | 104 (45) | 104 (38) | 1 (14) | 113 (40) | 91 (33) | 22 (15)*** |

[1] Diff - difference between the two udder halves

[2] ***- statistical significant difference P<0.001

The decreased plasmin and plasminogen-derived activity in the more frequently milk UH could partly be explained by an improved integrity of tight junction, as indicated by the decreased content of Na and increased K in milk samples collected from the UH milked four times a day (Table 4), which agrees with Sorensen et al. (2001).

Table 4. Content of Na and K (mmol/L) in udder halves (UH) milked twice daily in period one and one UH was milked twice daily while the contralateral was milked four times in period two, a.m. and p.m. milkings. Results are expressed as mean and standard deviation (SD); n=11

| | Period 1 (control period) milking frequency | | Diff[1] | Period 2 (experimental period) milking frequency | | Diff |
|---|---|---|---|---|---|---|
| | 2 x | 2 x | | 2 x | 4 x | |
| Na a.m. | 16.6 (2.9) | 16.4 (2.3) | 0.2 (1.2) | 15.1 (2.6) | 14.1 (1.9) | 0.9 (1.3)*[2] |
| Na p.m. | 16.0 (2.7) | 15.7 (2.2) | 0.3 (0.9) | 14.8 (2.9) | 13.8 (2.0) | 1.0 (1.4)* |
| K a.m. | 41.5 (4.3) | 41.5 (4.0) | 0.0 (1.0) | 41.8 (3.8) | 42.5 (3.6) | -0.7 (0.9)* |
| K p.m. | 41.7 (3.8) | 41.7 (3.8) | 0.0 (0.8) | 42.5 (3.7) | 43.4 (3.8) | -0.9 (0.7)** |

[1] Diff - difference between the two udder halves

[2] *- statistical significant difference P<0.05, ** - statistical significant difference P<0.01

## CONCLUSIONS

Increased MF had a negative effect on content of FFA in the milk while the level of plasmin decreased, indicating that increased MF is favourable for milk protein.

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