Influence of once daily milking and restricted feeding on milk characteristics in late lactation

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ABSTRACT

Forty-two identical twinsets were milked either once (ODM) or twice (TDM) daily and offered pasture and silage, either to appetite (H) or restricted to 50-60% of this level (L) for the last 5 weeks of the 93/94 season. Pretreatment, uninfected cows produced 8.45±0.28 l milk/d (mean±S.E) with a mean somatic cell count (SCC) of 37.1±3.3 x10^3cells/ml). Milk yields were significantly reduced ($P<0.001$) by L nutrition and by ODM. LogSCC was significantly increased ($P<0.05$) by L nutrition, due to reduced milk volumes but was not affected by ODM. Concentration of the serum-derived proteins, immunoglobulin G and bovine serum albumin, increased significantly for L nutrition and ODM. This suggests that involution had been accelerated in these animals, whose average daily milk yield was below 5 l/d. In late lactation milking should be discontinued for cows with milk yields of less than 5 l/d as involution may be initiated below this yield.

Keywords: Somatic cell count; once daily milking; nutrition; late lactation; cows.

INTRODUCTION

Undesirable changes in the processing characteristics of raw milk, obtained in late season, are often attributed to changes in somatic cell count (SCC) or the concentration of proteins derived from blood serum (Feagan, 1979). An increased SCC or serum protein content may arise from the normal decline in milk volumes or may signify the onset of mammary involution, a process that normally follows cessation of milk removal. During involution there is a reduced synthesis of the mammary-derived components i.e. lactose, casein, α-lactalbumin, ß-lactoglobulin and an increased transfer of blood-derived components, such as immunoglobulins (IgG), bovine serum albumin (BSA) and somatic cells into the milk (Hurley, 1989).

Once daily milking (ODM) in late summer is commonly practised in seasonal supply dairy herds to conserve pasture forage and cow condition while maintaining reasonable milk yields (Lynch *et al.*, 1991). Feed restriction contingencies, usually arising from drought conditions, may also reduce milk volumes prior to drying off. There are no clear guidelines available on the level of milk yield that cows may be milked down to while maintaining milk characteristics acceptable for processing. This experiment examined changes in milk yield, SCC and serum protein concentration associated with once daily milking and restricted feeding, treatments which reduced milk volumes during the last five weeks of lactation.

MATERIALS AND METHODS

Forty-two identical twinsets, predominantly of Friesian or Friesian x Jersey breed, of mixed parity and at 30-35 weeks into lactation were used in the experiment. Commencing in March 1994, all cows were fed pasture and silage (85:15) and milked twice daily for one week of uniformity. Cows were then milked either once (ODM) or twice daily (TDM) and fed either to appetite (H) or at 50-60% of this level (L) for up to 5 weeks prior to drying off. Feed rations remained at 85% pasture and 15% silage during the treatment period. A total of 21 animals were assigned to each of the four 4 treatments using a balanced, incomplete block design.

Milk yields were determined daily for all cows while representative p.m. and a.m. milk samples were collected on the fourth day of each week for analysis of milk composition. Milk fat, protein and lactose concentrations were measured (Milko Scan 133B Analyser, Foss Electric, Denmark) and milk SCC, using a cell counter (Fossomatic 450, Foss Electric). Serum-derived proteins, BSA and IgG, were measured using radial diffusion kits[1] for 12 cows of each treatment, 4 twinsets per treatment contrast. Data analysis utilised uniformity values as covariates. Milk SCC data were $\log_{10}$ transformed prior to analysis to compensate for the skewed distribution of somatic cell concentration in milk (Ali & Snook, 1980). Effects of milking frequency and level of nutrition for each parameter were determined for each week by restricted maximum likelihood (REML) analysis (SAS, 1994). This combines between-twin and within-twin contrasts to enable treatment effects to be estimated efficiently.

Milk samples were collected aseptically from all quarters for determination of bacteriological status (IDF, 1987) one week before treatments commenced and again during the third and fifth weeks of the treatments. Cows which were bacteriologically positive before the experiment were excluded from certain analyses to allow examination of physiological changes in the absence of infection. Cows were dried off during the experiment if their average daily yield over one week dropped below 3.6 l/d, in order to conserve cow condition. Otherwise cows were dried off at the end of the experiment irrespective of milk yield.

RESULTS

Cows in the L nutrition groups gave on average 30% (range 19-48%) less milk per day than their higher fed (H) counterparts (Figure 1). The effects of milking frequency were consistent for both nutrition treatments; ODM groups gave on

[1] Bovine IgG Normal Level, The Binding Site Ltd, Inst. of Research and Development, Birmingham, United Kingdom.

average 13% (range 8.5-16%) less milk per day than cows in the TDM groups. Of the 24 cows that required drying off before the end of the experiment, 3 were dried off at the end of week 2, 7 after week 3 and 14 after week 4 of the treatments. Since only 38% (8/21) of the L-ODM group remained in milk in week 5, milk composition results are given for week 4 (Tables 1 & 2).

Milk fat, protein, IgG and BSA concentrations in week 4 were significantly increased by L nutrition and by ODM (Table 1). Increases in IgG and BSA content contributed to the increases in total protein concentration. The L-ODM treatment resulted in a doubling of the IgG and BSA concentrations, associated with milk yields below 4.5 l/d. Lactose content was significantly reduced by L nutrition but was not affected by milking frequency.

During the experiment 8 quarters developed intramammary infections, including 7 by minor pathogens. No clinical infections were observed and no significant effect ($P > 0.05$) of treatment or milk yield was observed on incidence of new intramammary infection during the experiment or subsequent dry period. Daily milk yield per cow at drying off varied from 2.1 l/d to 15 l/d. Somatic cell concentration for cows which were bacteriologically negative throughout the experiment averaged 37.1±3.3 (±SEM) x10^3 cells/ml in the pre-treatment week. Low nutrition significantly increased ($P < 0.05$) log SCC during each week of the treatments, with cows on L nutrition showing more than a two fold increase in SCC after 4 weeks of the treatments (Table 2). Milking frequency did not significantly affect ($P > 0.05$) logSCC during the experiment. Total somatic cell production (SCP) was calculated as the product of daily milk yield and SCC. In weeks 1 to 4 log SCP was not significantly affected ($P > 0.05$) by either nutrition level or milking frequency.

FIGURE 1: Daily milk yield (l) of uninfected cows fed on a high (H) or low (L) level of nutrition and milked once (ODM) or twice (TDM) daily for the last 5 weeks of lactation. SED are denoted on the L-ODM treatment.

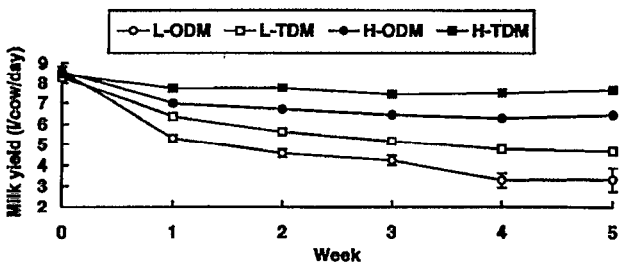

TABLE 1: Least squares mean values for milk yield and composition for cows on a high (H) or low (L) nutrition level, milked once (ODM) or twice (TDM) daily.

	n/group	MilkYield (l/d)	Fat (g/l)	Protein (g/l)	Lactose (g/l)	BSA (g/l)	IgG (g/l)
Pre-Exp.	12	9.22[a]	58.49[a]	37.69[a]	46.71[a]	0.243[a]	0.451[a]
Week 4							
L-ODM	8	4.22[b]	67.93[b]	43.33[c]	43.77[b]	0.423[b]	1.059[b]
L-TDM	10	4.95[c]	62.72[a]	41.55[b,c]	44.24[b]	0.359[c]	0.887[c]
H-ODM	12	6.75[d]	61.43[a]	40.42[b]	45.76[a]	0.306[d]	0.697[d]
H-TDM	12	8.01[e]	59.98[a]	37.84[a]	46.39[a]	0.241[e]	0.527[e]
S.E.D. Milk Freq.		0.25**	1.31*	0.88*	0.50[NS]	0.020**	0.061*
Feed Ration		0.25**	1.54*	0.90**	0.54**	0.021***	0.062***

*** Significant effect of treatment at probability <0.001
** Significant effect of treatment at probability <0.01
* Significant effect of treatment at probability <0.05
NS No significant effect
NB: Means within the same column but with different superscripts differ significantly at probability < 0.05

TABLE 2: Least squares mean values for daily milk yield, somatic cell count (SCC) and somatic cell production (SCP) for uninfected cows on a high (H) or low (L) nutrition level, milked once (ODM) or twice (TDM) daily.

Treatments	n per group wk4/wk 1	Milk Yield (l/d)	SCC (log10/ml)	SCP (log10)
Pre-Exp.	61	8.45[a]	4.SO[a]	8.42[a]
Week 4				
L-ODM	11/16	3.28[b]	4.98[b]	8.52[a]
L-TDM	9/13	4.76[c]	4.81[b]	8.47[a]
H-ODM	17/17	6.27[d]	4.64[a]	8.44[a]
H-TDM	15/15	7.48[e]	4.61[a]	8.51[a]
S.E.D. Milk Freq.		0.25***	0.072 NS	O 058 NS
Feed Ration		0.24***	0.075***	0.061 NS

*** Significant effect of treatment at probability <0.001
** Significant effect of treatment at probability <0.01
* Significant effect of treatment at probability <0.05
NS No significant effect
NB: Means within the same column but with different superscripts are significant different at probability < 0.05

DISCUSSION

The magnitude of the observed reduction in milk yield, associated with once daily milking, is in agreement with other experiments (Bryant, 1980; Carruthers and Copeman, 1990; Lynch *et al.*, 1991) and was similar, in percentage terms, for both nutritional challenges. The fall in milk yield observed for cows with restricted access to pasture was similar to that observed by Gray & Mackenzie (1987) where cows restricted to one third of normal pasture area experienced a 33% reduction in yield.

Increases in fat and protein concentration observed in response to ODM are consistent with previous findings (Carruthers *et al.* 1993; Lynch *et al.*, 1991; Kamote *et al.*, 1994). Increases in fat concentration in response to L nutrition are in agreement with Gray & Mackenzie (1987) but increases in protein concentration, due to L nutrition are contrary to previous reports (Gray & Mackenzie, 1987; Dawson & Rook, 1972). Levels of IgG and BSA are known to increase during late lactation (Feagan, 1979). The observed increases in concentration of these proteins may account for the significant increase in total protein concentration. Changes of the magnitude observed for the L nutrition treatment would seriously affect the processing value of milk (Feagan, 1979; Munro *et al.*, 1984).

The reduction in lactose concentration in response to L nutrition is in agreement with Dawson & Rook (1972). Reduced milk lactose, which has previously been observed during ODM trials (Carruthers *et al.*, 1993; Stelwagen *et al.*, 1994), may indicate disruption of the mammary tight junc-

tions. An increase in the concentration of serum proteins in milk, particularly BSA, also indicates loss of tight junction integrity (Stelwagen *et al.*, 1994) which is associated with the onset of involution (Bushe & Oliver, 1987). The results of the present study indicate that L nutrition, and to a lesser extent ODM, reduced milk yields to a level which accelerated the process of involution.

The total somatic cells secreted per cow was not affected by either reduced milking frequency or by restricted nutrition. Consequently, observed increases in somatic cell concentration for L nutrition, in the absence of infection, can be explained simply by the decline in milk volumes. In contrast, yield reductions induced by ODM were not associated with a significant change in log SCC. Kamote (1994) observed that ODM significantly increased the SCC of infected or high SCC cows but not that of low SCC cows. In the absence of infection, switching from TDM to ODM may allow milk yields to be reduced to a lower level before undesirable changes in SCC are observed. However, low milk volumes, of the order of 4-5 l/d in this experiment, were associated with high IgG and BSA levels, indicative of involution. It is suggested that milking is discontinued when milk yields drop below 5 l/d to avoid undesirable changes in serum protein content associated with involution.

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REFERENCES

Ali, A.K.A. and Shook, G.E. 1980. An optimum transformation for somatic cell concentration in milk *Journal of Dairy Science* **63:** 487-490.

Bryant, A.M. 1980. Once daily milking. *Aglink Farm Production and Practise No 158* Ministry of Agriculture & Fisheries, New Zealand.

Bushe, T. and Oliver, S.P. 1987. Natural protective factors in bovine mammary secretions following different methods of milk cessation. *Journal of Dairy Science* **70:** 696-704.

Carruthers, V.R. and Copeman, P.J.A. 1990. Once daily milking: what are the effects on productivity? *Dairyfarming Annual* 75-78.

Carruthers, V.R., Davis, S.R., Bryant, A.M., Henderson, H.V., Morris, C.A. and Copeman, P.J.A. 1993. Response of Jersey and Friesian cows to once a day milking and prediction of response based on udder characteristics and milk composition. *Journal of Dairy Research* **60:** 1-11.

Dawson, R.R. and Rook, J.A.F. 1972. A note on the influence of stage of lactation on the response in lactose content of milk to a change in plane of energy nutrition in the cow. *Journal of Dairy Research* **39:** 107-111.

Feagan, J.T. 1979. Factors affecting protein composition of milk and their significance to dairy processing. *The Australian Journal of Dairy Technology* **34** 77-81.

Gray, R.M. and Mackenzie, D.D.S. 1987. Effect of plane of nutrition on the concentration and yield of whey proteins in bovine milk. *New Zealand Journal of Dairy Science and Technology* **22:** 157-165.

Hurley, W.L. 1989. Mammary gland function during involution. *Journal of Dairy Science* **72:** 1637-1646.

International Dairy Federation 1981. Laboratory methods used in mastitis work. *Bulletin No.* **132**, IDF, Brussels, Belgium.

Kamote, H.I., Holmes, C.W., Mackenzie, D.D.S., Holdaway, R.J. and Wickham, B.W. 1994. Effects of once daily milking in later lactation on cows with either low or high initial somatic cell counts. *Proceedings of the New Zealand Society of Animal Production* **54:** 285-287.

Lynch, G.A., Hunt, M.E. and Mackenzie, D.D.S. 1991. The effects of once daily milking as a management practice in late lactation. *Proceedings of the New Zealand Society of Animal Production* **51:** 191-195.

Munro, G.L., Grieve, P.A. and Kitchen, B.J. 1984. Effects of mastitis on milk yield, milk composition, processing properties and yield and quality of milk products. *The Australian Journal of Dairy Technology* **39:** 7-16.

Stelwagen, K., Davis, S.R., Farr, V.R., Eichler, S.J. and Politis, I. 1994. Effect of once daily milking and concurrent somatotropin on mammary tight junction permeability and yield of cows. *Journal of Dairy Science* **77:** 2994-3001.