Differential effects of short-term once-daily milking on milk yield, milk composition and concentrations of selected blood metabolites in cows with low or high pasture intake.

M.J. AULDIST AND C.G. PROSSER[1]

Dairying Research Corporation Ltd., Private Bag 3123, Hamilton, New Zealand.

ABSTRACT

Forty-eight Friesian cows were subjected to *ad libitum* grazing (pasture allowance 45 kg/cow/day) or restricted grazing (pasture allowance 16-18 kg/cow/day) in a cross-over experiment during spring. Mean milk yields for *ad libitum* and restricted cows after 10 day treatment periods were 21.4 and 16.2 l/day respectively. All cows were then subjected to once-daily milking (ODM) for 2 days. ODM reduced milk yield and casein:whey protein ratios but increased concentrations of fat, serum albumin, immunoglobulin G, whey protein and somatic cells. Effects of ODM were greater in fully fed and thus higher-producing cows. In blood, ODM decreased concentrations of non-esterified fatty acids and urea, but increased concentrations of glucose. Milk yield and composition were significantly affected by short-term ODM, but the effect was less in cows producing below their peak due to feed restriction. There were metabolic indications that ODM reduced the nutritional demands of milk production.

Key words: Milk composition; milking frequency; once-daily milking, restricted grazing.

INTRODUCTION

In dairy cattle, once-daily milking (ODM) has been used to alleviate nutritional stress during periods of feed shortage, and has been advocated for the treatment of anoestrus during spring (Rhodes *et al*. 1998). There has also been speculation that switching from twice-daily milking to ODM could be a viable labour-saving management option (Carruthers *et al*. 1993; Stelwagen and Knight, 1997). The present study was designed to evaluate the effects of short-term ODM on milk yield and composition in cows fully fed on pasture, and cows in which milk yield was compromised due to a restriction in pasture allowance. Effects of ODM on the metabolic status of fully fed and underfed cows were also assessed.

MATERIALS AND METHODS

Experimental Design

Forty-eight multiparous Friesian cows were subjected to two nutritional treatments in a cross-over experiment during spring (an average of 60 days after calving). After a 14 day uniformity period in which cows grazed together *ad libitum*, half the cows were subjected to restricted grazing (pasture allowance 16-18 kgDM/cow/day) while the other half continued to graze *ad libitum* (pasture allowance 45 kgDM/cow/day). After 10 days of treatment, all cows were subjected to ODM for 2 days. All cows then grazed together *ad libitum* for a further 14 days, followed by a second 10 day treatment period during which cows received the alternative treatment. Again after 10 days, all cows were subjected to ODM for 2 days.

Cows grazed similar ryegrass/white clover pasture on adjacent paddocks throughout the experiment. Pre-grazing pasture mass for both treatments approximated 3600 kgDM/ha and was determined using a rising plate meter (L'Hullier and Thomson, 1987). Pasture restriction was achieved by restricting the area of pasture available to the cows.

Sampling and Analyses

Immediately prior to ODM, and on the second day of the ODM treatment, milk yields were recorded, and samples of the daily milk were collected from each cow using in-line milk meters. Milk samples were analysed for fat, protein, lactose, somatic cell count (SCC), nitrogen fractions, immunoglobulin G and serum albumin using the techniques outlined by Auldist *et al*. (1998). At the time of milk sampling, blood samples were collected from the coccygeal vein of each cow. In blood, concentrations of urea, non-esterified fatty acids (NEFA) and glucose were measured according to the methods described by Harris *et al*. (1998).

Data were analysed in SAS using the restricted maximum likelihood method of the mixed-model procedure.

RESULTS

Effects of ODM on milk yield and composition, and concentrations of selected blood parameters for cows on each nutritional treatment are presented in Table 1. ODM reduced ($P<0.01$) milk yield, casein:whey protein ratios and protein:fat, but increased ($P<0.01$) concentrations of fat, serum albumin, immunoglobulin G, total whey protein and SCC. Effects of ODM on milk yield and concentrations of lactose, BSA and IgG were greater for cows grazing *ad libitum* than for restricted cows. Concentrations of protein and casein were unaffected by ODM ($P>0.05$). In blood, ODM decreased ($P<0.01$) concentrations of non-esterified fatty acids and blood urea, but increased ($P<0.01$) concentrations of glucose. Effects of ODM for concentrations of

[1] AgResearch Dairy Science, Private Bag 3123, Hamilton, New Zealand.

TABLE 1: Effects of short-term once-daily milking (ODM) on milk yield, milk composition and selected blood metabolites in cows grazing pasture *ad libitum* or grazing a restricted pasture allowance.

	Twice daily milking		Once daily milking		Percent change		Significance		
	Ad libitum	Restricted	*Ad libitum*	Restricted	*Ad libitum*	Restricted	ODM	Diet†	Int.¥
Milk constituents									
Milk yield (kg/day)	21.4	16.2	17.2	13.9	-19	-13	**	**	**
Fat (g/kg)	44.5	43.4	48.8	47.6	+11	+12	**	NS	NS
Protein (g/kg)	35.2	31.9	35.1	32.0	0	0	NS	**	NS
Protein:fat	0.80	0.76	0.74	0.70	-7	-8	**	*	NS
Lactose (g/kg)	49.8	49.8	48.3	48.8	-3	-2	**	NS	*
Casein (g/kg)	27.6	25.0	27.2	25.0	-2	0	NS	**	NS
Whey (g/kg)	5.6	5.2	6.3	5.6	+13	+10	**	**	NS
Casein:whey	5.0	5.0	4.4	4.6	-11	-7	**	NS	NS
BSA (mg/l)	208	280	268	313	+31	+13	**	**	**
IgG (mg/l)	595	627	754	742	+27	+19	**	*	**
SCC (x1000 cells/ml)	58	43	155	69	+106	+57	**	NS	NS
Blood constituents									
NEFA (mM)	0.08	0.35	0.06	0.15	-15	-55	**	**	**
Urea (mM)	5.1	4.5	3.6	2.5	-19	-38	**	**	**
Glucose (mM)	3.7	3.6	4.0	3.9	+8	+9	**	**	NS

** P<0.01; *P<0.05; NS not significant (P>0.05); BSA, bovine serum albumin; IgG, immunoglobulin G; SCC, somatic cell count; NEFA, non-esterified fatty acids; † Signficance of diet effect prior to ODM; ¥ Significance of interaction between ODM and diet.

NEFA and urea in blood were greater for restricted cows than for cows grazing *ad libitum.*

It is noted that feed restriction had an effect on milk yield and composition; these data are presented in Table 1 to allow the changes due to ODM to be put into context.

DISCUSSION

Carruthers *et al.* (1993) reported that production losses due to ODM ranged from 10-28% in studies conducted over 2 to 12 weeks in early to mid-lactation. Stelwagen *et al*. (1994b) reported a 7% production loss due to ODM in a 2 week study, while Holmes *et al*. (1992) demonstrated a 35% loss due to ODM over a whole lactation. The reduction in mean milk yields due to ODM in the present study are consistent with those reported previously, but varied depending on the pasture allowance, and therefore milk yield, of the cows. This association between the extent of the response to ODM and the level of production of the cows may be one factor contributing to the wide variation in the production losses reported in the literature. Presumably, the greater production loss due to ODM in fully fed cows was because the mammary gland in these cows filled with milk earlier, inhibiting milk secretion for a greater proportion of the time between milkings. Nevertheless the actual mechanism for the reduction in milk yield is still uncertain (Stelwagen and Knight, 1997).

Data from a previous study at Ruakura (Stelwagen and Lacy-Hulbert, 1996) showed there was a transitory increase in SCC during ODM. In that study, SCC increased from below 50,000 cells/ml during twice-daily milking to 150,000 or above during ODM. A similar increase in SCC due to ODM occurred in the present study, but only for the cows grazing *ad libitum*. Further, although this effect was statistically significant, it was due mainly to large increases in SCC in two cows (to levels >1,000,000 cells/ml). Conversely, Stelwagen *et al*. (1994a,b) reported no increase in SCC during a two week period of ODM. Thus the evidence for the effects of ODM on SCC is contradictory and the reasons for the observed changes remain unclear. Nevertheless, increases in SCC and the production losses detailed above are major considerations for assessing the viability of using ODM as a labour-saving management practice.

The changes in milk composition due to ODM were consistent with an increase in the permeability of the mammary epithelia, and a subsequent influx of serum proteins (BSA and IgG) into the milk. Stelwagen *et al*. (1997) demonstrated that milk stasis during early lactation caused the tight junctions between the mammary epithelial cells to rupture after approximately 18 hours. This would facilitate the passage of serum proteins into milk from the extracellular fluid, as has been reported previously (Stelwagen and Lacy-Hulbert, 1996) and as was observed in the present experiment. Effects of ODM on the composition of milk were greater in the higher-producing cows, probably because a greater, accelerated distension of the mammary gland accentuated the leakage of blood components into milk (Stelwagen *et al*. 1994b). The changes due to the restricted pasture allowance prior to the commencement of ODM were consistent with those reported previously (Gray and Mackenzie, 1987; O'Brien *et al*. 1997; Petch *et al*. 1997).

These changes in milk protein composition due to ODM would generally be detrimental to the manufacturing potential of the milk, particularly but not exclusively for cheese manufacture (Lucey, 1996). Increases in the serum proteins would have contributed to the overall increase in total whey protein. Casein concentrations remained stable during ODM, despite previous observations that ODM increases the activity of milk plasmin, a proteinase known to hydrolyse ß-casein (Stelwagen *et al*. 1994a).

Nevertheless, increased concentrations of whey protein would have led to the decrease in casein:whey protein ratios. This ratio is a key index of the manufacturing quality of milk, since when cheese and caseinate are manufactured it is primarily the casein which is incorporated into the product. In addition, ODM induced a decline in the ratio of protein:fat in milk, which would also be detrimental to cheese yield efficiency (Lou and Ng-Kwai-Hang, 1992).

In blood, the changes brought about by ODM were indicative of an improvement in the nutritional status of the cows (Kolver and Macmillan, 1994). This was probably associated with a decline in the nutritional demands for milk production. Specifically, lowered concentrations of NEFA in the blood indicated a reduced mobilisation of adipose reserves, particularly in the cows with restricted pasture intake. Additionally, the increase in concentrations of blood glucose in all cows after ODM possibly indicates a lowered requirement for glucose for milk production, and an enhanced ability of the cows to maintain blood glucose reserves. Given that underfeeding can lead to problems with high levels of anoestrus in spring, these findings may provide support for the use of ODM to increase the spontaneous resumption of oestrus cycles in anoestrus cows.

In summary, ODM reduces milk yield and has marked effects on milk composition, at least in the short-term. These changes in milk composition would generally be detrimental to the suitability of milk for processing. Nevertheless, effects on milk yield and composition could be minimised by restricting the practice to cows not producing at their peak because of underfeeding. Changes in the concentrations of selected metabolites in blood are consistent with ODM alleviating nutritional stress, particularly in cows with a restricted pasture intake.

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