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The effect of stressors on milk yield and composition in dairy cows

G.A. VERKERK, A.D. FISHER[1], C.J. MORROW[1] AND L.R. MATTHEWS[1]

Dairying Research Corporation, Private Bag 3123, Hamilton
[1] Animal Behavioural and Welfare Research Centre, AgResearch, Hamilton, New Zealand

ABSTRACT

The effects of two stressors (level of feeding: 4% bodyweight, FI, and 3% bodyweight, RI; and altered lying time: free choice, LF, and prevention of lying from 1500 to 0645 h daily, LD) allocated in a 2x2 factorial design on milk yield and composition of Jersey cows (n=32) were studied. Stressors were applied for 7 days following an 8-day pre-treatment period. Composite milk samples were collected at milkings on days 2-3 of pre-treatment and during the last 4 days of treatment. Fat%, milk weight (am, pm and total daily) and mean daily yields of fat, casein, lactose and total milksolids were not affected by treatment. Protein%, protein yield and casein% were lower with RI (protein%: 3.66 and 3.53, sem=0.02, P<0.01; protein yield: 0.54 and 0.50 kg, sem=0.01, P=0.05; casein%: 2.84 and 2.77, sem=0.02, P<0.05 for FI and RI, respectively). There were no significant interactions between treatments. Protein content of milk was reduced by medium-term feed restriction, but lying deprivation had minimal effects.

Keyword: Dairy cows; stress; feed restriction; lying deprivation; milk composition.

INTRODUCTION

The late winter and early spring management of dairy cows in grazing systems often calls for the animals to be stood off grazing areas for periods of time. Environmental and social factors associated with this practice may result in cows failing to spend adequate time lying and resting. Munksgaard and Simonsen (1996) demonstrated that deprivation of free choice to lie for 14 hours each day over a 4 week period was aversive to cows which demonstrated altered behaviours and changes in the pituitary-adrenal axis. The stressors of transport and walking additional distances, when applied to dairy cows, have been shown to alter both milk weight and composition (Thomson and Barnes, 1993; Verkerk *et al.*, 1998), so the possibility exists that lying deprivation could also have a similar impact on production. A further factor of concern during the prevailing conditions of spring management is that the practice of standing off may lead to reduced feed intake. Medium-term feed deprivation will also result in changes in milk weight and composition (Auldist *et al.*, 1999).

The recognition of lying deprivation and feed restriction as potential stressors in the management practice of standing off has led to the need to question whether the practice is affecting dairy cow welfare. As part of a larger study into the physiological effects of deprivation of free-choice lying and feed restriction, we investigated the hypothesis that these stressors, applied over a period of 7 days, would alter milk yield and composition.

MATERIALS AND METHODS

Animals and Housing

The experiment was conducted at the No. 5 Dairy of the Dairying Research Corporation in Spring 1998, on lactating Jersey cows (n = 32; 4.4 ± 0.2 years old; 367 ± 6 kg). Cows were approaching peak lactation, being 29 ± 1 days postpartum at the beginning of the study. They were housed in a semi-enclosed barn facility, with animals in individual pens but in sight of the whole group, and able to interact with their immediate adjacent neighbours across a non-electrified wire. Milking occurred in the adjacent milking parlour.

Treatments

Cows were allocated to one of four treatments in a 2 x 2 factorial design, with two consecutive replicates, each of 16 cows. The experimental treatments were devised to simulate those stressors perceived to be operating under stand-off management. These were applied for 7 days, following an 8 day pretreatment period with free-choice lying and feeding to appetite.

Feeding level:

Two levels of feed were offered, being 4% (full intake: FI) and 3% (restricted intake: RI) of body-weight per day, on a dry matter basis. The ration consisted of fresh-cut ryegrass/clover pasture and pasture silage (as 70% and 30% of the calculated dry matter ration, respectively) and was fed after each milking. The animals also had access to a previously-grazed paddock area between 1000 and 1400 h each day.

Lying level:

Lying deprivation (LD) was applied for 15.75 hours each day (from 1500 to 0645 h) and was achieved by fitting cows with girth straps containing a modified electronic dog trainer unit (AgTronics Training Aid, AgTronics NZ, Auckland, New Zealand) activated by a pressure sensitive switch to deliver a short, high voltage, low energy stimulus. Animals which were allowed to lie on a free choice basis (LF) had plain girth straps attached during the same period. Behavioural observations were conducted for 24 hours during both the pre-treatment and treatment periods to measure cow lying duration.

Milk Sampling and Analysis

Total milk weights were estimated and composite milk samples were collected using in-line proportioning milk meters (Tru Test Co., Auckland, New Zealand) at each milking (morning milking: approximately 0600 h; afternoon milking approximately 0300h) on days 2 – 4 of the pre-treatment period and again on the last 4 days of the treatment period. Milk composition was analysed using an FT-120 auto-analyser (Foss Electric, Denmark), which determines the proportions of fat (fat%), total protein (protein%), casein (casein%) and lactose (lactose%) by near infra-red scanning technology. Somatic cell counts were assessed by Fossomatic (Foss Electric, Denmark).

Statistical Analyses

Results are given as mean ± pooled SEM. Data were analysed using Minitab v. 10Xtra (Minitab Inc., State College, PA, USA). Means for the two collection periods were calculated for the milk weight and composition variables for each cow then analysed using a GLM model by analysis of variance, with pre-treatment values as covariates and am/pm milking as a main effect. Mean daily weight and yield of milk components were calculated and analysed using a GLM model by analysis of variance, with pre-treatment values as covariates. Two cows, one each during the pre- and post-treatment periods, demonstrated a brief rise in somatic cell count which lasted for three days. Milk composition data for these cows were excluded from the analysis since mastitis is known to alter milk composition.

RESULTS

The behavioural observations showed that the lying deprived cows lay for 4 ± 0.3 h during a 24 hour period, whereas free-lying animals lay for 9 ± 0.8 h. Cows fed at the full intake level consistently left some ration indicating that they were being fed to appetite, while at the restricted level there were no refusals. The model stressors used in the treatments produced clear behavioural changes in the treated cows expressed as hunger and "tiredness".

TABLE 1: Covariate-adjusted means and standard errors (sem) for weight (kg), % components and daily yield (kg) of fat, protein, casein, lactose and total milksolids in milk from cows following either full or restricted feed intake and/or free lying or lying deprivation in a 2x2 factorial design. Differing superscripts within column (main effect) indicate significant difference (P<0.01 for protein%; P<0.05 for casein% and protein yield).

	Treatment				
	Feed Level		Lying		
	Full	Restricted	Free	Deprived	sem
Weight (kg)	15.6[a]	15.1[a]	15.6[a]	15.1[a]	0.3
% Components					
Fat	5.71[a]	5.58[a]	5.76[a]	5.53[a]	0.01
Protein	3.66[a]	3.53[b]	3.58[a]	3.61[a]	0.02
Casein	2.84[a]	2.77[b]	2.80[a]	2.80[a]	0.02
Lactose	4.93[a]	4.91[a]	4.90[a]	4.94[a]	0.02
Total milksolids	14.8[a]	14.6[a]	14.8[a]	14.5[a]	0.1
Daily yields (kg)					
Fat	0.90[a]	0.84[a]	0.90[a]	0.83[a]	0.03
Protein	0.54[a]	0.5[b]	0.53[a]	0.51[a]	0.01
Casein	0.44[a]	0.42[a]	0.44[a]	0.42[a]	0.01
Lactose	0.76[a]	0.74[a]	0.76[a]	0.74[a]	0.02
Total milksolids	2.32[a]	2.18[a]	2.32[a]	2.18[a]	0.06

The effects of the stressor treatments on milk weight, composition and daily yields of milksolids were minimal (Table 1). There were no significant effects of lying deprivation on any variable, or of feed restriction on milk weight, fat%, total milksolids% and daily yields of fat, casein, lactose or total milksolids. The covariate measurements taken during the pre-treatment period were significant for all variables ($P < 0.001$). There was a main effect of the level of feeding, such that protein% and daily yield of protein were lower in the restricted cows (protein%: 3.66 vs 3.53, sem = 0.2, $P<0.01$; protein yield: 0.54 vs 0.50 kg, sem = 0.1, $P = 0.05$, for fully fed vs restricted, respectively). The casein% varied with the main effect of nutrition but the casein yield only tended to differ (casein%: 2.84 vs 2.77, sem 0.02, $P<0.05$; casein yield: 0.44 vs 0.42 kg, sem = 0.01, $P<0.06$, for fully fed vs restricted, respectively). There were no significant main effects of the lying treatment, but there was a tendency for lactose% and daily fat yield to be greater in the lying deprived cows (lactose%: 4.94 vs 4.90, sem 0.02, $P<0.07$; daily fat yield: 0.90 vs 0.83 kg, sem = 0.03, $P<0.06$, for lying deprived vs free-choice lying, respectively).

Somatic cell counts were low throughout both milk sampling periods (overall mean 62.9 ± 16.0 and 64.4 ± 6.9 x 10^3 cells per ml for the pre-treatment and treatment periods, respectively) and were not influenced by the treatments.

DISCUSSION

The results indicate that when cows were exposed to model stressors designed to simulate the conditions of lying deprivation and feed restriction, as may be experienced during grazing stand-off periods in winter and early spring, there was minimal impact upon milk yield and composition.

The time spent lying by the free-lying group (9 ± 0.8 h) was similar to some previous reports for dairy cows, namely 8.6h (Singh *et al*., 1993) and 10h (Webster, 1986; Leonard *et al*., 1996); but was less than the free-choice lying times reported by Munksgaard and Simonsen (1996) where cows, tethered in bedded stalls and allowed free-choice lying, were observed to lie for 13.95 h each day. These animals may have expressed different behaviour patterns to the cows in this study which, although penned for the experimental period, were free to move about. The reduction in lying in this study, along with the behavioural expressions indicating "tiredness", suggest that this treatment achieved a moderately strong stressor challenge to the animals.

The tendency for an increase in lactose% and a decrease in daily fat yield with lying deprivation may simply be a spurious finding. It varies from results of previous investigations of the effects of stressors on milk composition. Thomson and Barnes (1993) noted an increase in fat% after 8 days of walking 4km per day; but milk weight decreased as did total fat yield, which was ascribed to the additional energy demands of the additional walking. Verkerk *et al.*, (1998) measured no change in milk compo-

sition although milk weight was reduced when cows were trucked for 1 hour before milking.

The observed effect of nutritional restriction on protein composition was similar to that seen previously when dairy cows, under a restricted grazing regime, had lower concentrations of protein and casein than cows which were fully fed (Auldist *et al.*, 1999). The principal variation between the Auldist *et al*. (1999) study and that reported here is that the milk yield was not reduced. While the level of feed restriction was similar in both experiments (70% of *ad libitum* intake) the cows in the former study were free-ranging, and so would have had an additional energy requirement for grazing activity unlike the cows in the model experiment.

These results indicate that the effect on milk production of management practices which stand dairy cows off pasture during periods of inclement weather may be minimal, except where it is accompanied by a period of nutritional deprivation. Although the behavioural evidence presented by those cows which were lying deprived suggested that they suffered some discomfort and tiredness, did not impact upon milk production.

CONCLUSION

A 7 day period of lying deprivation did not alter milk composition, weight, or daily yield of any milk component while feed restriction during this period resulted in reduced total protein and casein content of milk, but not their overall yield.

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