

Adaptation of the mammary oxygen consumption in response to milking frequency variations in dairy cows

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ABSTRACT

The aim of this experiment was to examine the adaptation of mammary energy expenditure in response to variations in milk yield induced by modifications of milking frequency. Three lactating cows were milked at 8-, 12-, 16- or 24-h intervals according to a Youden square with 5 periods of 7 days. When milking interval increased, milk yield decreased significantly by 24%, mammary blood flow significantly by 16% and oxygen consumption not significantly by 18%. As a result, the non significant decrease in the mammary oxygen consumption is associated with no reduction of the oxygen extraction but a decrease blood supply to the udder.

KEY WORDS: dairy cow, mammary gland, oxygen consumption, milking frequency

INTRODUCTION

Once daily milking leads to marked modifications of milk yield that can decrease to 30% compared to twice daily milking (Stelwagen, 2001). Such alteration of the milk components synthesis may involve a decrease of the mammary energy expenditure. Assuming that the udder oxygen (O₂) consumption is an indicator of energy expenditure, a study was conducted to determine the evolution of the mammary O₂ consumption in response to increasing milking intervals. In addition, to understand how the quantity of O₂ taken up by the udder is regulated, nycthemeral variations of mammary blood flow (MBF) and extraction of O₂ were examined.

MATERIAL AND METHODS

Three multiparous lactating dairy cows in mid lactation were milked at 8-, 12-, 16- or 24-h intervals during the last 7 days of 2 week periods according to a

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Youden square with 5 periods. One month before the beginning of the experiment, an ultrasonic flow probe (Transonic Systems Inc., Ithaca, NY) was implanted around the left external pudic artery and two permanent catheters were inserted into the left carotid and left subcutaneous abdominal vein (Rigout et al., 2002). Milk yield was measured daily during the experimental week as well as MBF, which was measured every minute.

The last day of each period, O_2 kinetics were determined from 12 blood samples taken simultaneously from the carotid and the milk vein over 24 h. O_2 concentration was measured by a gas analyser (ABL 625, Radiometer, Copenhagen). The mammary O_2 consumption was determined using the Fick principle (consumption = $MBF \times$ arteriovenous differences (AVD) of O_2). Averaged data were analysed following analysis of variance using cow, period and treatment as sources of variation according to the GLM procedure of SAS. Additionally time of day and time of day \times treatment interaction were added to the model to analyse kinetics data. Linear, quadratic and cubic responses of data were analysed by orthogonal contrasts.

RESULTS

Milk yield decreased curvilinearly from 37.7 to 28.7 kg/d for 8- and 24-h milking intervals, respectively ($P < 0.01$). Milk yield for 8-h treatment was not different from 12-h treatment (37.8 kg/d) and was decreased by 3.9 and 9.1 kg per day for the 16- and 24-h intervals. After 7 days of treatment, the daily average MBF decreased linearly with increasing milking interval (from 7.02 to 5.79 L/min; $P < 0.01$). Kinetics analysis of the MBF showed significant effect of time of day and time of day \times treatment interaction ($P < 0.01$ and 0.05, respectively; Figure 1).

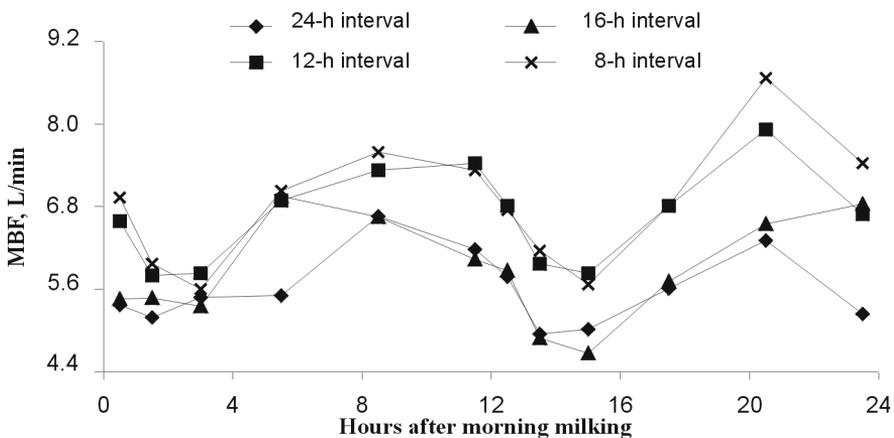


Figure 1. Nycthemeral kinetics of mammary blood flow (MBF) according to four milking intervals in dairy cows (time of day and time of day \times treatment interaction: $P < 0.01$)

Nycthemeral MBF kinetics curves were quite similar between treatments but MBF values were lower for 16- and 24-h treatments. After 7 days of treatment, the averaged O₂ arterial concentration tended to increase linearly and cubicly by 4.5% in response to increased milking interval (P<0.1; Table 1). The averaged O₂ AVD remained unchanged for all treatments.

Table 1. Mammary blood flow (MBF), oxygen arterial concentration, mammary arteriovenous difference (AVD) and consumption according to increasing milking intervals in dairy cows

	Milking interval, h				SEM ¹	Orthogonal contrast ²		
	8	12	16	24		L	Q	C
MBF, L/min	7.02	6.94	6.12	5.79	0.340	0.009	0.144	0.266
Oxygen								
arterial concentration, mmol/L	5.96	5.84	6.17	6.12	0.101	0.052	0.173	0.052
AVD, mmol/L	1.68	1.75	1.75	1.69	0.173	0.869	0.540	0.937
consumption, mmol/min	11.2	11.3	10.0	9.3	1.46	0.160	0.385	0.690

¹ standard error of the mean

² linear (L), quadratic (Q) and cubic (C) effects

The mammary consumption of O₂ decreased in response to treatments with increasing milking interval, but this was not significant (by 18% for 24-h treatment compared to 12-h treatment, P=0.16). Nycthemeral kinetics of O₂ AVD were significant with time of day (P<0.01), variations being opposite to those of MBF (Figure 2). Nycthemeral kinetics analysis of O₂ did not show a significant interaction between time of day and milking interval treatment.

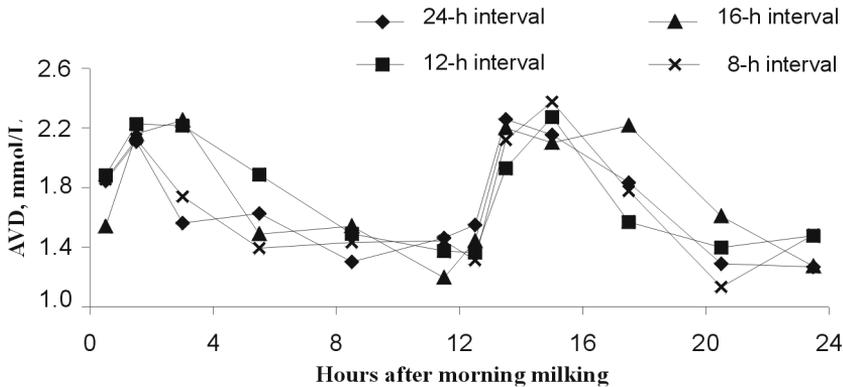


Figure 2. Nycthemeral kinetics of arteriovenous difference (AVD) of oxygen according to four milking intervals in dairy cows (time of day: P<0.01)

DISCUSSION

No significant variation in udder O₂ consumption with changes in milking frequency was observed in this study probably because of an insufficient number of animals. However, amplitude of the impairments of O₂ consumption and milk yield was quite similar (18 vs 24%, respectively) suggesting that the energy expenditure of the udder is diminished in response to the milk yield reduction caused by the increase of milking intervals.

The decrease of the mammary oxidative activity seems to be solely associated with a reduction of mammary blood supply without any change in the mammary extraction of O₂. Nycthemeral variations of MBF showed lower values throughout the day when milking interval increased. This result was previously reported by Guinard-Flament and Rulquin (2000) with dairy cows milked once daily. Prosser et al. (1996) supported the hypothesis of a regulation of the mammary blood flow by the udder that would regulate its blood supply to sustain its metabolism. In the present study, the udder could have reduced its blood supply to respond to the impairment of its ability to synthesise milk due to extended milking intervals.

CONCLUSIONS

The mammary gland seems to regulate its O₂ consumption not by decreasing the O₂ extraction but by significantly decreasing the blood supply in response to milk yield decreases due to milking frequency reduction.

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