Estimation of dairy cows ability to tolerate once-daily milking

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Abstract: A trial was conducted to determine whether the plasma lactose level is an indicator to assess the ability of dairy cows to tolerate once-daily milking (ODM), i.e. cows having low milk yield loss and full recovery in milk yield. Five blocks comprising 86 (Holstein x Normande) dairy cows in 2nd lactation were used over 2 years. The trial consisted in 3 successive periods: 1 control week at twice daily milking (TDM1), 3 weeks at ODM and thereafter, 2 weeks at twice daily milking (TDM2). Blood samples were collected 1 h before morning milking on d -3, 0, 1, 3, 7, 21, 23, and 28, d 0 being the last TDM1 day. After testing data normality, logarithmic transformation of lactose data set was performed before correlation study. Milk yield during TDM1 averaged 31.0 $\pm$ 4.8 kg/d. It decreased by 8.8 $\pm$ 2.7 kg/d on ODM and increased again by 4.3 $\pm$ 2.4 kg/d during TDM2. No correlation between control plasma lactose level and milk yield loss or recovery was observed. In contrast, plasma lactose level on d 1 was slightly correlated with milk yield loss ($r=0.21$; $P=0.05$) and more strongly with milk yield increase on TDM2 ($r=-0.46$; $P<0.0001$). During TDM2, dairy cows with high lactose plasma level on d 1 of ODM (> 350 mg/l), recovered less milk yield than others (about -2 kg/d). As a result, plasma lactose level on d 1 could be used to identify cows having lower milk recovery when switched back from ODM to TDM.

INTRODUCTION

Although once-daily milking (ODM) is not a spread rearing practice in France, it remains full of interest to fit the dairy production to punctual economic constraints (quotas, decrease in milk price), to relieve farmers during periods of strong workload in the farm, and in response to their aspiration of more spare time.

One of the causes of the weak development of this practice is doubtless the high loss in milk induced which can be associated with a negative residual effect on the production when cows switch back to twice-daily milking (TDM). Indeed, during the declining phase of lactation, milk yield is reduced on average by about 20-30 % for the period of ODM, and after 3 weeks the negative residual effect on production (in TDM) ranges between 2.4 to 8 % (Rémond and Pomiès, 2005). Furthermore, there is a high variability between dairy cows (Rémond and Pomiès, 2005; Holmes and al., 1992) which makes it difficult to predict the response to this practice and thus increases the risk-taking for the breeders. In these conditions, it seems interesting to find an indicator allowing to select cows which will lose little during ODM and/or which will recover more easily their production after this period.

Under the influence of milk accumulation into the udder, the milk soluble compounds, like lactose which is produced only in the mammary gland, diffuse through the mammary epithelium along concentration gradients. Therefore, the basal concentration of lactose in blood plasma is higher for animals milked once a day and increases rapidly after approximately 16 hours of milk accumulation into the udder (Delamaire and Guinard-Flament, 2005). Thus, ODM leads to an increase in the permeability of the mammary epithelium which could be directly correlated to the observed responses of milk yield. The concentration of lactose in blood plasma, which is a marker of the permeability of the mammary epithelium, could be consequently a predictor of this ability to tolerate ODM.

The aim of the present study, from a relatively consequent experimental population, is double:

- on the one hand, to examine the variability of the loss when switching cows from TDM to ODM and the variability of the recovery in milk yield when switching cows back to TDM after 3 weeks of ODM, as well as the relationship between both;
- on the other hand, to determine if the concentration of lactose in blood plasma is correlated to the loss (ODM) and/or to the recovery (TDM) in milk yield, and could be a good candidate to predict the responses of cows to ODM.

MATERIALS AND METHODS

The experiment involved 99 crossed Holstein / Normande dairy cows (F2: second generation) from the INRA experimental farm of Pin-Au-Haras (Larroque and al., 2002). The trial took place during 2 successive milk campaigns where the cows were distributed in 5 blocks. All the cows were in second lactation, with an average stage of lactation of 80 days and an average age at calving of 43 months. The cows were kept indoors in a loose housing system on manure pack, and they were fed once a day at 8 am. They received the same diet throughout the experiment (based on grass silage, corn silage and energy concentrate) formulated according to the requirements for cows milked twice a day.
The experimental scheme was conducted during 6 weeks and divided into 3 periods: 1 week of control where cows were milked twice a day (TDM1), then 3 weeks of ODM, followed by 2 weeks of twice-daily milking (TDM2). The animals were milked at 6:30 am and 5:00 pm in the periods of twice-daily milking and at 8:00 am during the ODM.
Two samples of blood were taken in the tail of the animals 1 hour before morning milking and 5 hours later, on day -3 during TDM1, on days 0, 1, 3, 7, 21, 23 during ODM, and on day 28 during TDM2 (day 0 being the first day of ODM). The concentration of lactose in plasma was assayed using a colorimetric enzymatic reaction (kit for lactose/D-galactose, Scil Diagnostics GmbH, Meylan, France). Milk yield was recorded every day. To determine fat and protein contents, samples of milk were collected from Monday till Thursday during all the experiment as well as in the daytime of blood sampling. Finally, 13 cows were excluded from the analysis because of mastitis or inconsistent milk data, and thus 86 were retained for the study as described in the Table 1.

Table 1: Number of cows, and stages of lactation and ages at calving (mean) per block.

Block	Milk campaign	Number of cows	Stages of lactation (days)	Ages at calving (months)
1	2004/2005	21	81.7	40.4
2	2004/2005	24	82.3	42.3
3	2005/2006	7	81.4	42.1
4	2005/2006	17	79	42.0
5	2005/2006	17	68.5	46.0

Daily milk yield data were averaged according to the period (except for TDM2: averaged data from the 2nd week), and a logarithmic transformation was used for lactose concentrations in blood plasma, in order to make sure of their normality before the Pearson correlation study.

RESULTS AND DISCUSSION

Milk

- From TDM1 to ODM

During the control period (TDM1), on average, the cows produced 31.0 kg/d of milk with a fat and protein content of 42.8 and 31.5 g/kg respectively. The variability of the level of production was high with a coefficient of variation (CV) of 15.4 % (Table 2). The lactation stages being homogeneous and the feed identical for all, this heterogeneity of the production level was mainly due to the genetic origin of the animals.

During the ODM period, on average, the cows produced 22.1 kg/d of milk with a fat and protein content of 46 and 31.9 g/kg respectively. The variability of the production levels was relatively high (CV=16.3%).
During the transition from TDM1 to ODM, the cows lost 8.8 ± 2.7 kg/d of milk, i.e. 28 ± 7 % ($P < 0.0001$) of their production (Table 3). Milk yield losses, absolute and relative, were higher when the initial production level was high ($r = -0.66$ and -0.22; $P < 0.0001$ and $P=0.04$, respectively). But for the same initial level, there was an important between-cows variability (Figure 1) as described by Rémond and Pomiès (2005). For example, for an initial level of 38 kg/d, the milk loss ranged between -6 kg/d to -14 kg/d (i.e. -15.8 to -37 %).

Table 2: Milk yield (kg/d)

	TDM1	ODM	TDM2
Mean	31.0	22.1	26.4
Min	21.2	13.1	17.8
Max	40.3	31.4	35.2
Std	4.78	3.62	4.38
CV	15.4	16.3	16.6

Table 3: Variations in milk yield, absolute (kg/d) and relative (%)

	TDM1/ODM		ODM/TDM2	
	(kg/d)	(%)	(kg/d)	(%)
Mean	-8.8	-28	+4.3	+19.8
Min	-14.4	-47	-0.6	-2.6
Max	-3.5	-13	+10	+49.5
Std	2.67	6.82	2.43	11.67
CV	-30.3	-24	56.9	59

- From ODM to TDM2

During TDM2, on average, the cows produced 26.4 kg/d of milk with a fat and protein content of 43.4 and 32.9 g/kg respectively (Table 2). This represented on average a gain in milk of 4.3 ± 2.4 kg/d compared to the previous period of ODM, i.e. 19.8 ± 11.7 % (Table 3).
The absolute gains in milk production were not correlated with the quantity of milk produced during ODM. However, the relative gains in milk were moderately and negatively correlated with the level of milk yield during ODM ($r=-0.27$, $P=0.0107$): the more the cows produced during ODM, the less they tended to recover (relatively) during the resumption of TDM (Figure 2).

- Relationship between loss in milk yield (from TDM1 to ODM) and gain in milk yield (from ODM to TDM2)

The levels of milk production were strongly and positively correlated between TDM1 and ODM periods, and ODM and TDM2 periods ($r=0.83$ in both cases, $P < 0.0001$): the more the cows produced during the control period (TDM1), the more they produced during ODM and TDM2 periods.

Figure 1: Absolute loss in milk yield during ODM according to the control milk yield (TDM1)

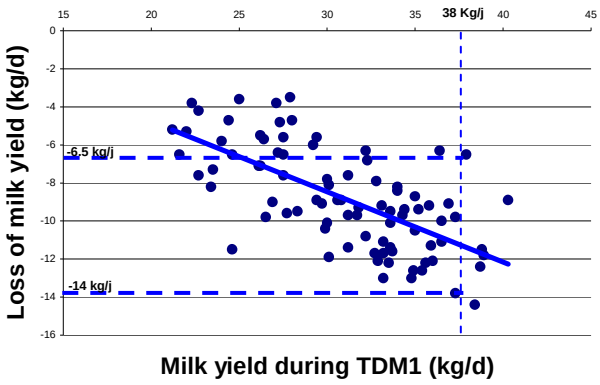
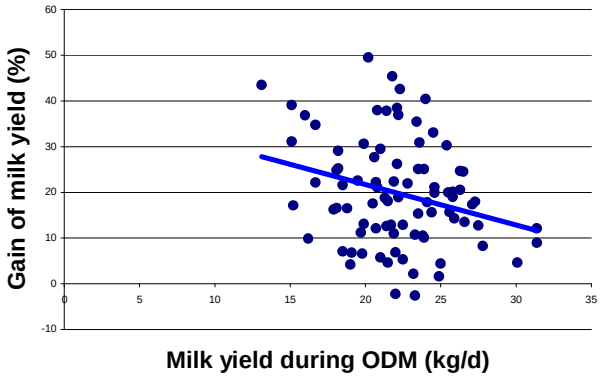
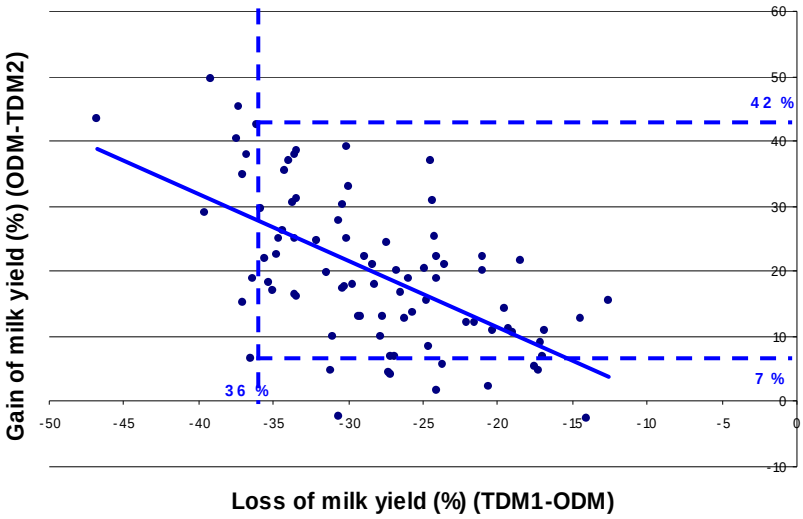


Figure 2: Relative gain in milk yield during TDM2, according to the level of milk yield during ODM.



However, the gains in milk yield when switching back to TDM remained lower than the loss in milk yield caused by ODM: on average, the animals got back 4.3 kg/d of milk against 8.8 kg/d of loss. The estimation of TDM2 milk production (with no ODM period) by using a lactation persistency of 98% per week revealed a 6 % residual loss in milk yield in this trial. These results are in agreement with those of Rémond and Pomiès (2005). These authors reported a residual loss in milk yield of 8 % after a 3-week ODM period at a similar stage of lactation (9 weeks).
The more the animals lost when switched to ODM, the more they recovered when switched back to TDM, and this in absolute (r=-0.59, P < 0.0001) as well as in relative (r=-0.60, P < 0.0001). As shown in Figure 3, there was also a strong variability of the gain according to the loss: for example the cows having lost 36 % of production have recovered between 7 and 42 % during TDM2.

Figure 3: Relative gain in milk yield (from ODM to TDM2) according to the relative loss in milk yield (from TDM1 to ODM).



Lactose in blood plasma

Lactose concentrations in blood plasma were measured to assess the effect of the milk accumulation into the udder on the mammary epithelium permeability. Control lactose concentrations (mean values of d-3 and d0) were measured after 12-14 hours milk accumulation into the udder and averaged 21.4 ± 11.1 mg/l. After the 1st 23 hours of milk accumulation (d1 of ODM), the lactose concentrations in plasma were increased up to 183.4 ± 148.4 mg/l.
The mean values of the control lactose concentrations in blood plasma (logarithmic transformation) were not correlated to the level of milk yield during ODM, nor to the relative loss in milk yield (Table 4). On the other hand, the concentrations of lactose measured at the beginning of ODM (at d1) were weakly correlated with milk yield during ODM, as well as with the relative loss in milk yield (Table 4). The cows with the strongest relative loss in milk yield didn't show a high increase in their concentration of lactose in blood plasma after 23 hours of milk accumulation into the udder (Figure 4).
When switching back to TDM, the control concentrations of lactose in blood plasma were not correlated to the average milk yield during TDM2, nor to the relative gain in milk yield (Table 4). Also, the concentrations of lactose measured at d1 were not correlated to the milk yield during TDM2. On the other hand, these concentrations were rather strongly correlated to the relative gain in milk yield when switching back to TDM (r = 0.46 and 0.41 respectively; P < 0.0001) (Table 4). The lower the gain in milk yield was, the higher the increase in lactose concentration after 23 hours of milk accumulation into the udder was (Figure 5). The cows with a concentration of lactose in blood plasma higher than 350 mg/l have recovered 2kg/d of milk which showed fewer compared to the others (Figure 6).

Table 4: Correlations between concentrations of lactose in blood plasma measured before morning milking (after logarithmic transformation: LB), and milk yield (and variations in milk yield) during ODM and TDM2.

	ODM		TDM2	
	Milk yield (kg/j)	Loss in milk yield (%)	Milk yield (kg/j)	Gain in milk yield (%)
$LB_{control}$	ns	ns	ns	ns
$LB_{d\,1}$	0.296 **	0.210 *	ns	-0.46 ***

***=(P<0.001), **=(P<0.01),*=(P<0.05)

Figure 4: Relative loss in milk yield when switching cows from TDM1 to ODM, according to the concentration of lactose in blood plasma measured before the morning milking at d1 (after logarithmic transformation: LB)

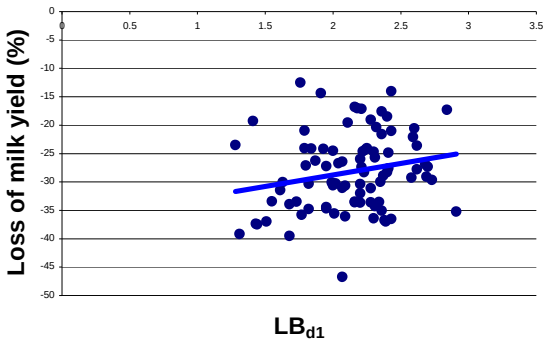


Figure 5: Relative gain in milk yield when switching cows from ODM to TDM2, according to the concentration of lactose in blood plasma measured before the morning milking at d1 (after logarithmic transformation: LB)

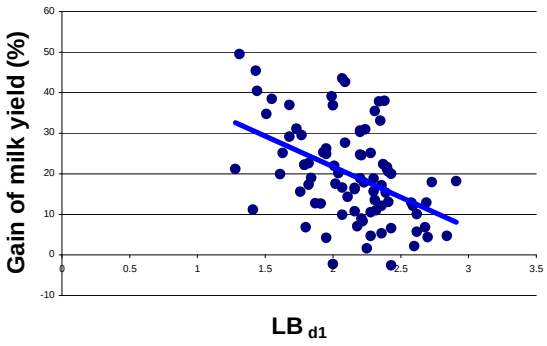
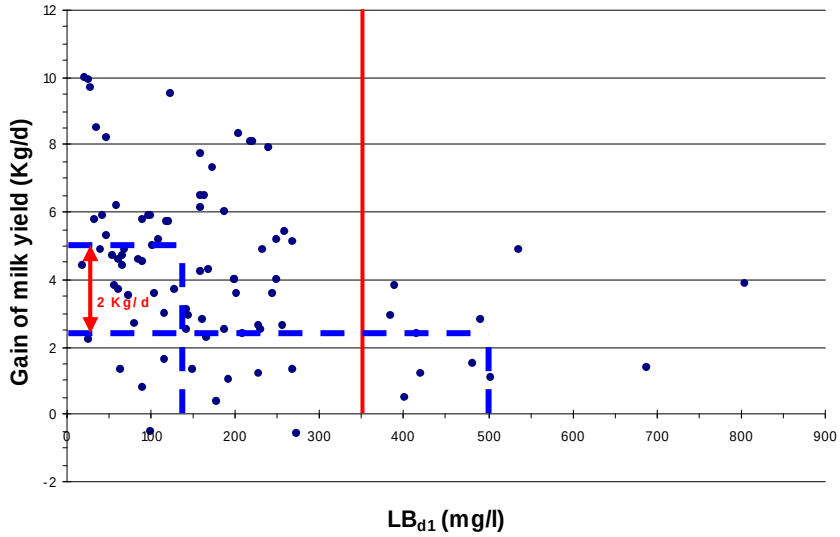


Figure 6: Gain in milk yield (from ODM to TDM2) according to the concentration of lactose in blood plasma measured before the morning milking at d1



CONCLUSIONS

Even if the relative losses in milk yield and the relative gains in production are highly correlated, there is an important between-cows variability: the loss in milk yield cannot give a good estimation of the milk recovery after 3 weeks of ODM. As a consequence, after 3 weeks of ODM, the loss in milk production (from TDM to ODM) and the gain (from ODM to TDM) seem to have to be considered as 2 different traits which characterize the capacity of cows to tolerate ODM. These heterogeneous individual responses suggest a genetic variability which remains to be investigated. The underlying phenomena of this variability seem to be associated with the integrity of the mammary epithelium at the beginning of ODM. Indeed, assuming the concentration of lactose in blood plasma to be an indicator of the mammary epithelium integrity, it appears to be a relevant indicator of the variations in milk yield, especially during the return to TDM, when measured at the beginning of ODM, i.e. after the 1st 23 hours of milk accumulation into the udder.

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