Do Automatic Milking Systems affect the shape of the lactation curve?

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Summary

In the automatic milking systems (AMS) milking frequency is variable among cows and between days within cows. Since milking frequency is related to many factors associated with secretion rate and udder evolution and involution, we may expect that the AMS can affect curve of lactation. Measures of milk yield persistency were made in two experiments comparing Italian Friesian primiparous cows reared in an automatic milking system or in a conventional 8+8 herringbone milking parlour system. In the first experiment 10 cows per group were used. In the second experiment 5 pairs of twins were compared. In our experimental conditions, variability of results obtained didn't give sufficient evidence of a different persistency caused by the milking systems. In the AMS group, persistency was found to be correlated with milking frequency, milking interval, and with their variability. These correlations let to suppose that cows with higher and more regular milking frequency could have higher persistency.

Key words: *Dairy cow, automatic milking system, lactation curve, persistency, milking frequency*

Introduction

Measuring the effect of AMS on milk yield (MY) is a complex challenge because of many methodological and technical aspects. Surveys performed to investigate the changes in farms that adopted AMS evidenced a variable improvement of milk yield associated with milking frequencies ranging between 2.3 and 2.8 milking/day. Pre-planned experiments comparing conventional systems (CS) and AMS showed contradictory results. However the extent of MY increase obtained with the AMS seems currently to be lower then early expectations. This is probably due to difficulties to adapt management to such new system. Most of early studies on AMS were conducted in the North of Europe, where the AMS was first adopted. In Italy, Ministry of Agricultural Politics and Regione Lombardia granted research projects in order to evaluate effect of AMS on the peculiar aspects of Italian dairy farms. Here, we present some results regarding the shape of lactation curve from two experiments comparing AMS and CS. Effect of AMS on persistency of lactation is a still open question and few data are currently

available; however some considerations can be argued from the more known relations between milking frequency (MF) and milk secretion in CS. Since MF is related to many factors associated with secretion rate and udder evolution and involution, we may expect that the AMS can affect curve of lactation. Long intervals produce the increase of the endo-mammary pressure that limiting secretion rate. Moreover, long intervals allow a more effective action of chemical factors limiting milk secretion that are otherwise removed more frequently when cows are milked with shorter intervals. The critical interval is not the same for all cows because it depends on the udder capacity. Also nutrient uptake in the udder is affected by interval milking, raising until 8h and decreasing after. Even short intervals can result in an immediate MY reduction because of the lack of availability of cisternal milk. In CS, frequent milking (4 or 6 times per day) at the beginning of lactation showed an effect on MY that persisted even after frequent milking end (Bar-Peled *et al* 1995, Hale *et al*, 2003, Dahl *et al*. 2004). These effects were related with the increase in mammary growth during early lactation and with a delay of the involution process in late lactation (Capuco et al. 2003). Moreover, MF affects permeability of tight junctions (TJ). Increased TJ permeability was associated with MY shortage when cows were milked once daily. Stelwagen *et al*. (1994) showed a temporary disruption of TJ when cows were milked once a day. Low MF was also demonstrated to increase the activity of plasminogen, plasmin and plasmin activator in milk (Stelwagen et al 1994). Since plasmin–plasminogen system was related to the involution of mammary tissue in late lactation, increasing MF was expected to maintain persistency of lactation. However, in the AMS, MF is variable and irregular; there are cows milked more than thrice and cows milked less than once a day; an herd average of 3 milking per day (that could be considered an optimal goal) can be obtained with regular intervals (about 8 hours each) o with irregular intervals (i.e. two short intervals and one long interval). During the first two years of AMS usage at the Porcellasco Farm, the average MF of 2.56 was obtained with 50% of cows ranging between 2.5 and 3.0 milkings per day; more than 30% of cows had an average of 2.0-2.5 milkings per day ; 2% of cows were milked less than twice and 6.6% of cows were milked more than trice daily. The 9604 considered milkings were performed after an average interval of 9 h 23 min 50 s, with the 12.5% of milkings occurring after an interval shorter than 6 h, the 19% of milkings occurring after intervals longer than 12 h; 4.5% of intervals were longer than 16 h. (Speroni et al 2003). In CS it was demonstrated that regularity in milking improves MY. Bach *et al*.(2004) showed that also in the AMS irregular intervals may have detrimental effect on MY.

Matherial and methods

The two trials were carried out in the experimental barn of the Animal Production Research Institute, at the Porcellasco Research Farm. The barn was a free stall house with cubicles.Two similar herd of 45-50 Italian Friesian cows were housed on the opposite side of the barn. On one side, the cows were milked twice a day in a conventional 8+8 herringbone

milking parlour (CS), on the other side there was a single box AMS (DeLaval VMS™). Both groups were fed with the same TMR distributed once daily in the morning. Cows in AMS received also a concentrate supply in the milking stall. Guided cow traffic was adopted in the AMS so that animals were forced to pass the milking area before entering the feeding area. A pre-selection gate prevented cows which had recently been milked to pass the milking stall and deviated them directly to the feeding area. In the AMS, the set minimum milking interval was 5h and it was the same for all cows in the herd and for all stage of lactation. Cows in the CS had milking intervals of 11 h and 13h. In the CS, MY was recorded weekly (for two consecutive milkings); in the AMS, MY and MF were recorded continuatively. Daily MY means of the AMS were calculated on four consecutive days as representative of a week. BCS were scored before and after calving regularly.

Experiment 1. Before calving, 20 heifers, were assigned to the two experimental groups which resulted comparable for average breeding value, expected age at first calving, expected calving date. At the beginning of lactation, the primiparous were introduced in the two herds (AMS or CS). The following repeated mixed model was tested to evaluate the effect of milking system on MY from 1 to 41 weeks in milking (WIM): **(1)** $Y_{ijk} = \mu+\alpha_i+d_{ij}+\tau_k+(\alpha\tau)_{ik}+e_{ijk}$, where Y_{ijk} and e_{ijk} were respectively the daily MY and the error for the cow j in the milking system i, at WIM k; μ, α,τ ($\alpha\tau$) were fixed factors: μ = mean effect; α = milking system effect (i=AMS, MP); τ = WIM effect (k=1 to41); ($\alpha\tau$) =interaction between milking system and WIM; d_{ij} was the random effect associated to j^{th} *cow* in the ith milking system. Resulting least square means were fitted by a regression with the log linear form of Wood function ($\ln MY=\log_e a+ b\log_e WIM +cWIM$). Persistency was calculated as -(b+1)lnc; distance between calving and peak was calculated as b/c; e MY at peak was calculated as $a(b/c)^b e^{-b}$. The following mixed model, in which WIM was introduced as covariate together with interaction between milking system and WIM, was tested to estimate if a common slope model would be adequate to describe the data from the 11th to the 41 week and from the 22nd to the 41st week for both AMS and CS: **(2)**$Y_i =\alpha_{cs} +(\alpha_i-\alpha_{cs}) +\beta_{cs}x_{ij}+(\beta_i-\beta_{cs}) x_{ij} +bj + e_{ij}$, where i= AMS, CS; 11-41 or 22-41; α_I and βi are respectively the intercept and the slope for the ith milking system model; bj is the effect of WIM; e_{ij} is the random experimental unit error.

Experiment 2. Five pair of twins were used to compare milk production in CS vs AMS. After calving each heifer was introduced in the herd. One of the six pair was eliminated from the analysis because the twin assigned to the AMS had trouble in the training with the milking system. Three couple were examined until 24 weeks. Only two could be analysed until 38 week an later. Model **(1)** was used to test the effect of milking system on MY 1 to 24 WIM (5 pairs) and from 1 to 40 WIM (two pairs). Model (2) was tested the slope from 11WIM to 21WIM. Udder morphology was scored around 10 WIM.

In both experiment persistency was also calculated by the ratios between MY in different stage of lactation and correlated with individual traits.

Results

Experiment 1. The pattern of least square means for MY was reported in Figure 1 together with the Wood's curves. Average correlations among MY measures within cows calculated as the ratio between the animal variance component ($ó_c$) and the sum of animal variance plus the random residual variance ($ó_c + ó_r$) was 45%. Although their MF averaged 3.00 ± 0.53 milkings/day, AMS heifers produced the same as the MP heifers on average and at each week, except at the 27th week when AMS group produced less than CS group (P= 0,022). Parameters for Wood's curves are reported in table 1; R^2 were 0.93 and 0.83 for AMS and CS respectively. Analysis of curves slopes in the late lactation (>21 WIM) didn't provide sufficient evidence to conclude the slopes were unequal, but when the middle lactation data (>11 WIM) were also considered the AMS curve had a significantly lower slope (P=0.01) than the CS one. Other measures of persistency are reported in table 2. They tend to be lower in the AMS were some of them resulted positively correlate with MF and negatively correlated with milking interval (MI) and variability of MY, MF and MI (table 3.). BCS and BCS variations were equal for the two groups and they didn't result significantly correlated with persistency.

Experiment 2. Average MF from week 0 to week 21 for the five heifers in the AMS was 2.59±0.50. There was not a significant effect of milking system on MY. However, when comparison was made within pairs, two pairs resulted in higher MY (P<0.01) in the AMS and three pairs in the CS. The average pattern of MY was reported in figure 2. Slopes of curves between 12 to 22 WIM were equal. Also persistencies, measured as 12-22 WIM/1-11 WIM, were very similar (1.08 and 1.05 for the AMS and CS respectively). Pattern of the pairs of twins that had complete lactation data are reported in figure 3 -5. In one case persistency of AMS measured as the ratio between MY in late lactation and in early lactation heifer was higher (0.92 vs. 0.62) but in the other case persistency of the two curves are very similar (1.00 and 1.03 for AMS and CS heifer respectively). BCS and BCS variations were equal for the two groups. Persistency didn't result significantly correlated neither with BCS and BCS variations nor with udder morphology traits.

Conclusions

A higher individual variability was observed in our experiments. On average, we didn't get sufficient evidence of the improvement in MY persistency that we could expected as a consequence of a higher MF. On the contrary, in most of cases, MY persistency tended to be higher in CS. Poorer persistency in the middle lactation of AMS group could be explained by an underfeeding of energy or nutrient deficiency due to an higher requirement of heifer in the AMS but our data do not provide enough information to support any of these hypothesis. However, between persistency and MF and MI traits were found correlations that let to suppose that cows with higher and more regular MF could have

higher persistency. Further investigations are needed about the nutritional aspects and the individual traits that can influence effect of AMS on the MY. Promising fields are cistern capacity measurement and consistency of individual feeding and moving behaviour.

Table 1. Experiment 1. Parameter of Wood's curves.

	a	b	c	(b+1)lnc	b/c	$a(b/c)^b e^{-b}$
AMS	25.3	0.2	-0.025	4.579	9.63	34.296
CS	24.1	0.2	-0.018	4.922	12.54	34.125

Table 2. Experiment 2. Measures of persistency of lactation curve.

	Persistency measured as ratios between MY at different stage of lactation				
	41 WIM/ at peak	12 - 22 WIM/ 1-11 WIM	22 - 41 WIM/ 1 - 11 WIM	12 - 41 WIM/ 1-11 WIM	average/ max
AMS	0.615±0.043	0.956±0.050	0.806±0.037	0.906±0.033	0.724±0.027
CS	0.735±0.043	1.042±0.050	0.892±0.035	0.967±0.033	0.826±0.027*

*P< 0.05

Table 3.Experiment 2. Correlations between persistency and MY, MF and MI in the AMS.

	Persistency measured as ratios between MY at different stage of lactation				
	41 WIM/ at peak	12 - 22 WIM/ 1-11 WIM	22 - 41 WIM/ 1 – 11 WIM	12 - 41 WIM/ 1-11 WIM	average/ max
CV of MY	-0.75*	-0.40	-0.73	-0.47	-0.96*
Average MF	0.61	0.47	0.54	0.47	0.76*
CV of MF	-0.51	-0.45	-0.42	-0.50	-0.70*
Maximum MI	-0.50	-0.44	-0.67*	-0.53	-0.67*
Average MI	-0.66*	-0.54	-0.69*	-0.41	-0.70*
CV of average MI	-0.66*	0.03	-0.76*	-0.33	-0.29

*P< 0.05

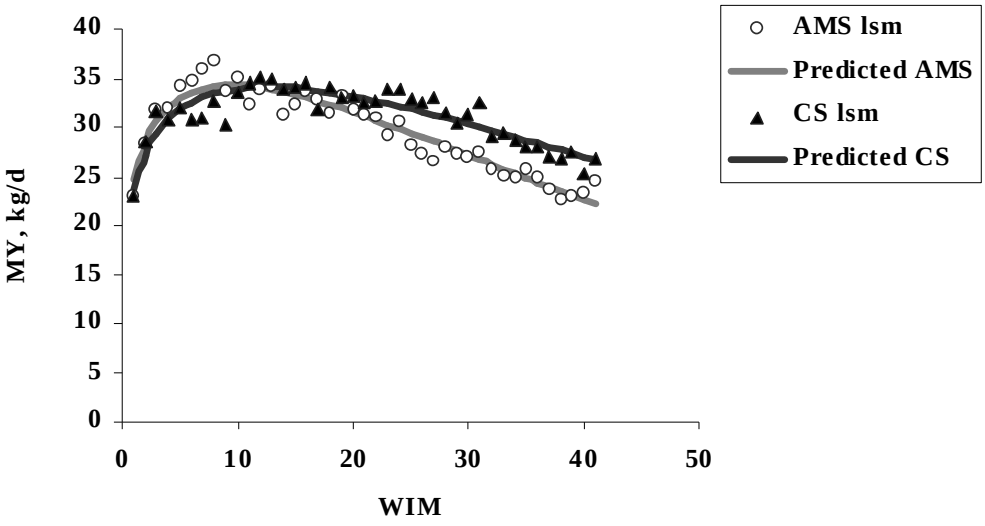

Figure 1.Experiment1. MY pattern: Least Square Means and Wood functions.

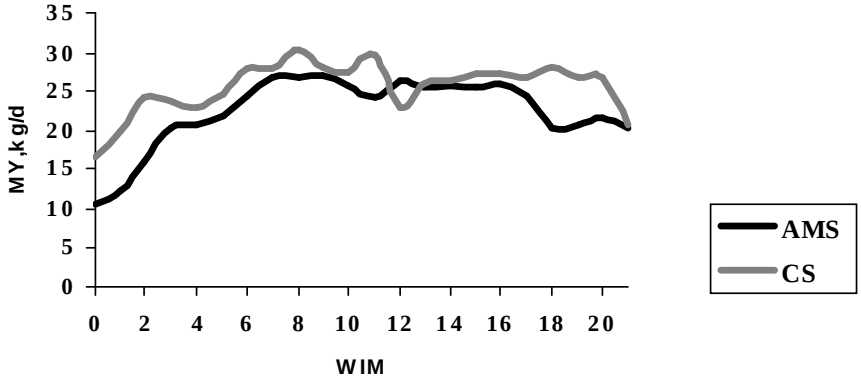

Figure 2.Experiment2. MY pattern: least square means (5 twin pairs).

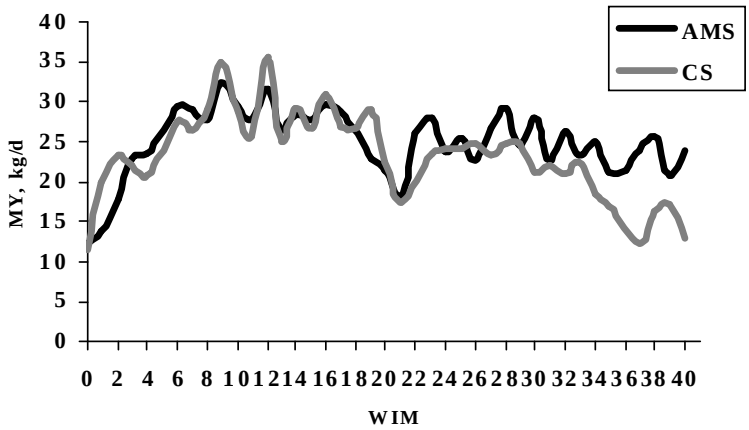

Figure 3. Experiment3. MY pattern: least square means (2 twin pairs)

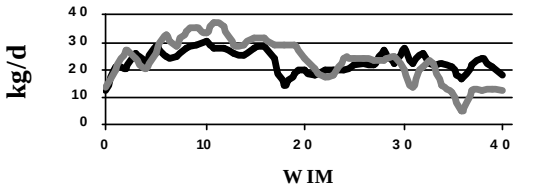

Figure 4. Experiment2. MY pattern: least square means of pair n° 1.

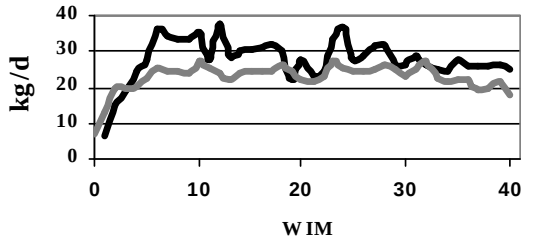

Figure 5. Experiment2. MY pattern: least square means of pair n° 2

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