Milking procedures, milk flow curves and somatic cell count in dairy cows

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RIASSUNTO – Modalità di mungitura, curve di emissione del latte e cellule somatiche. *Il lavoro ha avuto lo scopo di studiare le relazioni esistenti tra le curve di emissione del latte, la routine di mungitura, la produzione e il numero di cellule somatiche (come linear score). Il campione di 3089 bovine, monitorate in 89 aziende lombarde, ha mostrato un'elevata percentuale di curve bimodali (36%). La bimodalità è risultata più elevata nei casi di ridotta o nulla preparazione della mammella e nei casi di breve intervallo tra stimolazione e attacco delle tettarelle. Le curve bimodali sono risultate significativamente associate a minore produzione lattea, minore durata della fase di plateau e maggior linear score (LS) rispetto alle curve normali. All'aumentare del LS si è riscontrato un significativo calo della produzione per munta, un aumento del flusso massimo, una sensibile riduzione della durata della fase di plateau e un aumento della conducibilità elettrica. Inoltre a elevato LS è risultata associata una elevata incidenza di curve bimodali.*

Key words: milk flow, somatic cell count, milk ejection, dairy cow.

INTRODUCTION – Recent availability of electronic mobile milk flow meters allows to study in details milk flow patterns during milking. A normal milk flow profile is characterized by an incline phase, with increasing milk flow, a plateau phase, with steady milk flow, and a decline phase. In these phases milk flow is influenced by many factors: genetic characteristics of the cows, regulation of milking machine and milking routine. Premilking operations affect in particular the timing of milk ejection mechanism. In fact, milk is stored within two compartments of the mammary gland, the cistern and the alveolar tissue, and only the cisternal milk is immediately available for milking; the alveolar milk can only be removed if the mechanism of milk ejection has occurred. Tactile stimulation of the teats (i.e. cleaning) activates a neuroendocrine reflex resulting in the oxytocin release that causes the contraction of the myoepithelial cells surrounding the alveoli and the milk letdown (Bruckmaier and Blum, 1998). The ejection of alveolar milk takes about 1-2 min from stimulus, depending on the filling level of the udder (Bruckmaier, 2001). If the cow is not prepared before milking, alveolar milk can be removed only 1 min after the cup attachment that represents, in this case, the source of stimulus. As a consequence, the flow curve shows bimodality due to a temporary collapse in the milk flow registered after removal of the cisternal fraction.

Good flow profiles depend on a good balance among man, machine and physiological/anatomic characteristics of the cow and are considered to be related to good milk production, short milking time and good udder health. Several authors reported an advantage in milk flow rates and machine on-time by optimizing teat stimulation and time between stimulation and attachment of teat cups (Sagi *et al.*, 1980a, b; Gorewit and Gassman, 1985; Rasmussen *et al.*, 1992) but only a few studies showed a positive effect on milk yield (Mayer *et al.*, 1984; Merrill *et al.*, 1987; Rasmussen *et al.*, 1990). Moreover, in the international literature, there is a lack of studies about the relationships between milking procedures, milk flow curves and udder health. Tancin *et al.* (2002) report-

ed a significantly higher somatic cell count in milk from cows with a longer duration of the decline phase but only at the single quarter level.
The aim of the present study was to describe the milk flow curves and to investigate the relationships with milking operations, milk production and udder health, as somatic cell count.

MATERIAL AND METHODS – The study was carried out in 89 herds in Lombardy, where 3089 milk flow profiles were measured with Lactocorder®, an electronic mobile milk flow meter. Data from milk flow meters were associated with the data from a questionnaire about milking routines and the data from individual milk recordings performed by the Provincial Breeders Associations. Somatic cell count, converted into linear score (LS), was the mean of the last 6 recordings. All the data were analysed by GLM procedure; the statistical models always included the effects of parity (1, 2, >2) and stage of lactation (DIM; <140, 140-280, >280 d).

RESULTS AND CONCLUSIONS – Milk yield per milking was, on average, 13.8±4.6 kg, with maximum milk flow rate of 3.8±1.2 kg/min. The bimodality was present in a high percentage (36%) of milk flow curves. Total milking time was 6.9±2.4 min with a high incidence (40.7%) of milkings longer than 7 min. The long duration of the decline phase (2.7±1.4 min) is probably due to the sequential ending of milk ejection of less producing quarters; this result suggests the tendency to overmilk one or more quarters, also when threshold setting of automatic detacher is right. The time of overmilking phase (detachment delay when milk flow is very low) was rather long (0.8±1.1 min; 12% of milking time) causing an unnecessary increase of labour costs and teat stress. Machine stripping was applied by few farms (18% of the monitored cows). The time of the stripping phase was 1.1±0.9 min (16% of total milking time) but stripping milk was only 0.6±0.7 kg (4% of total milk yield).
Correlation analysis showed a positive relation between milk yield and average flow rate (r=0.51; P<0.001) and between milk yield and time of the plateau phase (r=0.43; P<0.001). LS was inversely related to time of the plateau phase (r=-0.23; P<0.001) but did not have any correlation to the duration of the other phases.
Most of milk flow parameters were influenced by DIM and number of parity (table 1), mainly as a consequence of different milk production levels.

Table 1. Milk flow parameters as a function of parity and stage of lactation (least squares means)

		Parity				DIM			
		1	2	>2	SEM	<140	140-280	>280	SEM
No. obs.		590	378	445		361	550	502	
Milk yield	kg/milking	13.5^{B}	14.8^{A}	14.8^{A}	0.23	16.1^{A}	14.6^{B}	12.4^{C}	0.20
Maximum milk flow rate	kg/min	3.6^{B}	3.9^{A}	4.0^{A}	0.06	3.8	3.9	3.8	0.07
Bimodality	%	36.3	34.2	31.0	25	26.5^{B}	31.8^{B}	43.2^{A}	26
Time of plateau phase	min	2.6^{Aa}	$2.3A^{Bb}$	2.1^{Bc}	0.09	2.9^{A}	2.4^{B}	1.7^{C}	0.09
Time of decline phase	min	2.4^{Bc}	2.8^{Ab}	3.1^{Aa}	0.07	2.9	2.7	2.7	0.08
Peak milk conductivity	mS/cm	6.2^{C}	6.5^{B}	6.7^{A}	0.04	6.4^{Bc}	$6.5A^{Bb}$	6.6^{Aa}	0.04
LS		2.9^{B}	3.0^{B}	3.6^{A}	0.08	2.9^{Bc}	3.1^{ABb}	3.4^{Aa}	0.09

$^{a, b, c}$ P<0.05; $^{A, B, C}$ P<0.001.

As expected, the prolongation of the interval between pre-stimulation and unit attachment was associated to a strong decrease in bimodality (from 45% for interval <30 s to 26.7% for interval >60 s; P<0.001). Moreover bimodality was significantly affected by premilking operations: 50.8% in the group without any preparation and 27.4% (P<0.001) in the group with full preparation (teat cleaning, predipping and forestripping).
Bimodal curves resulted in lower milk yield per milking (13.8 *vs.* 14.6 kg/milking; P<0.001), higher maximum flow

rate (4.1 *vs.* 3.7 kg/min; P<0.001), longer incline phase (1.28 *vs.* 0.69; P<0.001) and much shorter plateau phase (1.7 *vs.* 2.6 min; P<0.001) compared with normal curves. Peak electrical conductivity of milk and LS were significantly higher in bimodal group (6.8 *vs.* 6.3 mS/cm, P<0.001; 3.3 *vs.* 3.0, P<0.001) in comparison with normal group. Grouping the curves as a function of LS of milk (table 2) allowed to highlight some differences about the milk flow parameters: from the lowest to the highest class of LS there was a significant decrease in milk yield, time of plateau phase and time of decline phase, and an increase in the maximum flow rate, the percentage of bimodality and the peak milk conductivity.

Table 2. Milk flow parameters as a function of linear score (least square means).

		LS			
LS classes		<2	2-4	>4	SEM
no. obs		343	647	381	
Milk yield	kg/milking	15.5^{A}	14.5^{B}	13.5^{C}	0.23
Maximum milk flow rate	kg/min	3.6^{B}	3.9^{A}	3.9^{A}	0.07
Bimodality	%	$28B^{b}$	35^{Aa}	39^{Ab}	2.6
Time of incline phase	min	0.86	0.89	0.92	0.02
Time of plateau phase	min	2.8^{A}	2.3^{B}	2.0^{C}	0.09
Time of decline phase	min	3.0^{A}	2.7^{B}	2.7^{B}	0.08
Time of overmilking phase	min	0.71	0.65	0.80	0.06
Peak milk conductivity	mS/cm	6.3^{C}	6.5^{B}	6.7^{A}	0.04

$^{a, b, c}$ P<0.05; $^{A, B, C}$ P<0.001.

Milk flow curves showed suboptimal profiles: overmilking must be shortened, stripping could be avoided and bimodality could be reduced by means of a proper teat preparation. In fact high bimodality was in connection with insufficient or absent premilking operations and with a short interval between preparation and teat cups attachment. Bimodal curves resulted in lower milk yield and higher LS compared with normal curves and high LS group had lower milk yield, higher maximum flow rate, higher milk conductivity and higher percentage of bimodality in respect to low LS group.

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