Efficiency of cleaning procedure of milking equipment and bacterial quality of milk

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ABSTRACT - The cleaning and sanitation of milking equipment could be consider a critical point in the milking procedure because a cleaning failure could influence the level of bacteria contamination of bulk tank milk. Aim of the study is to monitor the cleaning procedures of milking systems in 7 dairy cows farms in Lombardy and to find a relation between efficacy of cleaning system and the bacterial quality of bulk tank milk, remaining washing water through milking equipment and teat cup surface. Cleaning procedures were monitored with Lactocorder, that measured: duration, water temperature, turbulence, percentage of water in pipes, water conductivity of pre- and post-rinse and detergent phases. Results showed that the monitored farms the most of the cleaning parameters were lower than recommendations, in particular maximum water temperature (42.1±9.9°C) and percentage of water during detergent phase (76.1±13.9 %). A maximum temperature of detergent phase <40°C determined a high Standard Plate Count (SPC), thermoduric bacteria and Coliform Count (CC) of bulk tank milk, SPC and CC of teat cup surface. The research indicated that monitoring the efficiency of cleaning milking equipment with proper tools provide useful information about possible sources of contamination of bulk tank milk. Improving cleaning milking efficiency allow to improve milk quality.

*Key words***:** Cleaning, Milking system, Bacterial quality.

Introduction – Cleaning and sanitation of milking equipment could be considered a critical point in the milking procedure, because a cleaning failure could influence the level of bacteria contamination of bulk tank milk. Milk residues or remaining washing water, left on milking equipment contact surface, support the growth of a variety of microorganisms (Murphy and Boor, 2007; Holm et al., 2004).

The most common parameter to determine the bacterial quality of bulk tank milk is the Standard Plate Count (SPC), for this parameter there is a legal limit. SPC has a little diagnostic value in determining the source of bacterial contamination because an high value could be due to many factors such as low efficacy of cleaning milking equipment, poor milk cooling, poor teat and udder hygiene and presence of mastitis bacteria. A better indicator to understand the efficacy of cleaning systems is thermoduric bacteria presence. In fact they survive to pasteurization conditions and they growth and multiply in the milk equipment, in particular in old craked rubber parts, if the cleaning and sanitation procedures are inadequate, especially with the use of cold water (Murphy and Boor, 2007; Reinemann *et al*., 2003). Coliforms' source in the milking equipment and bulk tank milk could be soil and manure on the teat and udder surfaces. Coliforms count provides indications of cleanliness of cows' environment, effectiveness of teat preparation before milking and efficacy of sanitization of milking equipment (Reinemann *et al*., 2003).

Cleaning of milking equipment is accomplished by a combination of chemical, thermal and physical processes which when combined, have a minimum reaction time to be effective. Cleaning and sanitation solution provides chemical cleaning action, heating water and solution provides thermal energy and the turbulent flow solutions through pipes and equipment produces mechanical energy.

Aim of the work was to monitor the cleaning procedures of milking machines in some dairy cows farms and to study the relation between efficacy of cleaning system and the bacterial quality of bulk tank milk, remaining washing water and teat cup surface.

Material and methods – The study was conducted on 10 commercial dairy cattle herds in Lombardy (Italy) with 95 (±65) dairy cows on average and with herringbone milking parlour (9 farms) or tie-stall milking system (1 farms). Herds were kept in free-stall housing systems with cubicles in 9 farms, in tie-stall barn in one farm. Each farm was visited twice during summer to collect questionnaire data concerning farm characteristics and management practises. Cleaning milking process was measured twice for each farms during afternoon milking, with a continuous electronic milk flow meter (Lactocorder) with a proper setting. Lactocorder measures: water temperature (average, minimum and maximum), water conductivity, water flow, water turbolence and duration of each washing phases. Bulk tank milk samples at the end of milking and water samples at the end of cleaning of milking equipment were analyzed to determine SPC (Standard Plate Count was performed according to ISO 4833:2003), thermoduric bacteria or Laboratory Pasteurized Count (LPC, SPC on milk heated to 63 °C for 30 min) and Coliform Count (CC) (CC, ISO 4832:2006). Teat cups were swabbed before milking to determine SPC and CC of the internal surface (approximately 30 cm^2). Data were analyzed by using GLM models (SAS Institute, 1991).

Results and conclusions – The cleaning regime was divided by Lactocorder in three main phases: pre-rinse, detergent-phase and post-rinse in 7 farms. In the other 3 farms there were 4 or 5 phases. We considered only the results of the 7 farms that are shown in table 1. The duration of the three phases was different: the second phase (detergent) was much longer (751±243 s) than the other two, in this way the contact with the alkaline detergent and disinfectant with milking equipment surface was more efficacy. Reinemann *et al*., (2003) suggested a duration longer than 10 min for this phase. Maximum temperature of the detergent phase was higher than in the rinse phases but resulted lower than recommendations, Reinemann *et al*. (2003) and Codeluppi (2003) suggested a water temperature higher than 45°C to insure a proper disinfection of milking equipment. Water temperatures of the two rinse phases were slightly lower than recommendations. As expected the variation of water temperature per min (ΔT) was higher in the second phase than in the others. Water conductivity was important to define the post-rinse efficacy: the results showed that in these farms the water conductivity was higher in the third phase than in the first phase and they suggested an insufficient water rinse to remove residual cleaning solutions. The parameter "water %" gives information about the uniform distribution of water flow through milking pipes, water percentage values under 100% indicate a water flow lower than 2 kg/min (WMB, 2008). The washing cleaning systems of the 7 farms showed a low

Table 1. Cleaning milking system characteristics of the 7 farms (mean, SD).

		Pre-rinse phase		Detergent phase		Post-rinse phase	
		Mean	SD	Mean	SD	Mean	SD
n		12		14		14	
Time of phase	s	303	66	751	243	353	115
Water T min	°C	17.4	2.7	26.8	3.8	17.7	2.7
Water T max	"	23.6	7.5	42.1	9.9	23.2	4.1
Water T mean	"	19.2	4.1	33.3	5.3	18.6	2.9
ΔT	°C/min	1.1	0.8	1.2	0.4	1.0	0.6
Conductivity	mS/cm	3.5	1.4	60.6	21.7	4.8	2.3
Water	%	53.9	18.9	76.1	13.9	50.4	18.3
Turbulence	"	33.1	12.8	45.6	20.5	41.7	18.2

Table 2. Effect of water maximum temperature during detergent phase on bulk tank milk, teat cup surface and water post-rinse bacterial quality (Least Square-Means).

		Water max T<40°C	Water max T>40°C	SEM
n		7	7	
SPC bulk tank milk	Log_{10} CFU/ml	5.08	4.43	0.315
LPC bulk tank milk	"	2.6	2.4	0.216
CC bulk tank milk	"	3.79[a]	2.48[b]	0.389
SPC swab after washing	Log_{10} CFU/cm^2	3.46	2.9	0.291
CC swab after washing	"	1.13	1.01	0.112
SPC water rinse	Log_{10} CFU/ml	2.84	2.37	0.506
LPC water rinse	"	1.96	1.95	0.005

a, b *P*<0.05.

percentage of water in particular in the detergent phase, where the distribution of detergent solutions was particularly important. Turbulence represents steady air admission used to produce the two-phases (air-water) that reduce the required water volume, increase flow speed during cleaning and improve cleaning action of water-detergent solutions. In this case turbulence was higher in the second and third phases in comparison with the first phase, although the values were lower than Manufacturer's recommendations (WMB, 2008).

The efficacy of cleaning of milking systems could be defined by microbiological analysis of bulk tank milk, as suggested by Reinemann *et al*. (2003). The results showed (table 2) that the maximum water temperature of detergent phase (MWT2) had a significantly effect (P<0.05) on Coliform Count of bulk tank milk: in particular a temperature lower than 40°C during cleaning determined an increase in these bacteria. MWT2 had not significant effects on SPC and LPC of bulk tank milk, probably due to the low number of observations, but these parameters showed higher values if MWT2 was lower than 40°C, these values are higher than recommended and legal limits (Murphy and Boor, 2007). Similar trend was found for teat cup surface and water post-rinse.

The results obtained showed that in these 7 farms cleaning procedure of milking system could be improve in particular for water temperature during rinse and cleaning and water flow rate. The research reveals that monitoring the efficiency of cleaning milking system with proper tools provides useful information about possible sources of contamination of bulk tank milk. Improving cleaning milking efficiency allow to improve milk quality.

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