A Field Study on Teat-End Vacuum in Different Milking Systems and its Effect on Teat Condition

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The amount of vacuum in the proximity of the teat depends on vacuum settings of the system but also on cross-section of milk and air lines, milking system components and design, as well as on, e.g., pulsation settings. The vacuum level has an influence on the speed of milk removal but also on teat barrier function and its ability to prevent infections of the teat canal and of the udder (Hamann et al. 1993). Due to the close interaction between teat, liner and vacuum, a response of the teat condition is a direct variable to evaluate improper design or settings of milking systems (Mein et al., 2003; Neijenhuis, 2004). The aim of the study was to investigate the amount of and variation in teat-end vacuum during milking, depending on milk flow and milking system characteristics, such as low and high placed milking line. Secondly, the aim of the study was to get a deeper insight into the interactions between milking system characteristics, pulsation settings and teat condition.

Material and Methods

Teat end vacuum, milk flow and teat condition were measured at twelve dairy farms in Northern Germany. Farm 1 to 4 were equipped with a conventional milking system, farm 5 to 8 with a swing-over parlor and farm 9 to 12 with special technology, such as alternative air inlet position (farm 9, 10) or positive pressure pulsation (farm 11, 12). Data were sampled during one milking time per farm. Operational vacuum was measured at the beginning of milking, close to the milk receiver. Pulsation and teat-end vacuum during milking-time (measured in the short milk tube; BoviPress©; Boventis GmbH, Germany); milk flow (LactoCorder©, WMB AG, Switzerland); general pulsation characteristics (MilkoTest MT52©, Bepro AG, Switzerland); and touch point pressure difference (TPPD) of liners were recorded at one milking unit (m_1) per farm. The morphology of teats and udder, teat color and ring at teat base after milking were investigated at all animals that were milked at m_1. In addition, hyperkeratoses were scored visually at nearly all cows per farm and general farm and performance data were recorded. The overpressure or compressive load that was applied to the teats by the closing or closed liner (Mein et al., 2003) was calculated based on vacuum in the short milk and pulse tubes and TPPD, excluding farm 11 and 12.

Results

Teat-end vacuum during the maximum vacuum phase (phase b) at a milk flow of 1 kg/min varied between 28 kPa and 39 kPa depending on milking system and operating vacuum (Table 1). It dropped down to a level of 20 kPa to 35 kPa at a milk flow of 3-4 kg/min (recorded during milk flow plateau). Swing over systems had to provide a higher operating vacuum than milking systems with a low milking line in order to maintain sufficient teat-end vacuum during milking time. Likewise, vacuum drop during the maximum vacuum phase and vacuum fluctuations during increasing and decreasing vacuum phase were higher in systems with alternating compared to simultaneous pulsation. Further influences on vacuum level at teat end were air inlet design, and flow restrictions in components, milk tubes and lines, such as milk flow indicators or milk meters.

Table 1: Vacuum Level (kPa) in Different Milking Systems, Depending on Milk Flow

Farm	Operating vacuum	Pulsa-tion	Teat-end vacuum at a milk flow of...				Milk flow P^1 (kg/min)
			1 kg/min	2 kg/min	3 kg/min	*P^1 kg/min*	*n = 1*
1	43	alt	35	34	31	27	***3,8***
2	42	sim	39	37	36	35	***3,5***
3	39	alt	35	34	31	30	***3,5***
4	42	alt	35	32	28	27	***3,3***
5	44	alt	39	(38)	-	(32)	***(2,4)***
6	42	alt	38	27	23	20	***3,5***
7	46	sim	39	36	32	29	***3,5***
8	46	sim	38	35	32	30 / 26	***3,0 / 4,0***
9	35	alt	28	26	23	22	***3,2***
10	41	sim	34	32	28	25	***3,7***
11	44	sim	35	33	32	28	***3,5***
12	37	sim	32	29	27	24	***4,0***

[1] Vacuum level that belongs to a milk flow plateau *P* of 3-4 kg/min (one selected cow per farm)

Cows milked in swing-over systems (farm 5-8) featured in average less hyperkeratoses but more blue colored teats and more severe rings at teat base after milking than cows milked in conventional systems (farm 1-4). Cows milked in systems with alternative air inlet design or with positive pressure pulsation featured in average less blue colored teats and less severe rings at teat base after milking but more hyperkeratoses than cows milked in conventional systems. Significant influences ($p < 0.05$) on hyperkeratosis score were: teat end shape, compressive load, positive pressure pulsation, pulsation rate and ratio, TPPD, duration of over milking, and herd lactation yield. Front teats as well as round or pointed teat end shapes featured more often moderate up to severe findings.

Conclusions

Teat-end vacuum was influenced by milk flow level, milking system, system components and milking settings. Operating vacuum is not a sufficient measure to characterize the quality of milking. Teat-end vacuum, milk flow patterns and the response of teats to the milking process are preferred indicators for evaluating milking system design and settings. Nevertheless, up-to-date there is still only sparse understanding of optimal settings and design for optimized complete, rapid and gentle milk removal.

References

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