Consideration of Teat Morphology and Milking Characteristics for Robot Milking Conditions

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Many fundamental milking practices are based on the assumption that the cow will be milked with conventional milking equipment. Among these are that all cows will be milked with the same milking cluster, with similar preparation procedures, and the milking cluster will be removed from all 4 teats at the same time.

Robot milking challenges this traditional approach and allows for freedom of many of the practical limitations of the conventional milking cluster and can take into consideration individual variables for each teat. Quarter yield and single cup removal are improvements already offered by the new technology. Robotic arms are also capable, in principle, of selecting a teat cup that is best suited to each teat. The milking routine can also be executed according to predefined milkability conditions. This work investigates some new possibilities for research and milking practices presented by the unique capabilities of robotic milking machines.

A trial was conducted to evaluate the effect of teat morphology on milking characteristics in order to identify opportunities to improve milking if a robot arm were able to select preferred teat cups for individual teats. Milk flow curves differed between cows with different front teat morphology ("classical"- C, and "conical"- CO). Cows with C teats demonstrated more well-defined flow periods (rapidly increasing, peak flow plateau, and rapidly decreasing milk flow). These well defined flow periods were not as apparent in cows with CO shaped front teats. This suggests sub-optimal milking for CO cows possibly as a result of teat congestion and/or teat sinus occlusion because of excessive teat tissue penetrating into the milking liner as milking proceeds.

A second trial examined the characteristics of mouthpiece chamber vacuum of short and long teats with two different liners. A popular narrow bore US liner (control, BouMatic R-2CV) and a wide bore European liner (treatment, BouMatic DKFS). The maximum, minimum and average mouthpiece vacuum for the entire milking was recorded. The results for the control liner for each teat length group are shown below in Table 1.

Table 1. Mouthpiece chamber (MPC) vacuum data for control liners.

Teat length cm	Number of teats	MPC vacuum (kPa) Maximum	Average	Minimum
< 4	12	30.7^{a}	20.4^{a}	9.3^{a}
4	8	27.5^{b}	18.8^{ab}	8.7^{ab}
> 4	20	26.6^{b}	15.4^{b}	5.1^{b}

$^{a, b}$ significant differences within columns.

When milked with the control liner, teats less than 4 cm in length had a significantly ($p<0.05$) higher maximum, minimum and average mouthpiece vacuum than teats greater than 4 cm. When milked with the treatment liner, all teat length groups experienced a significant increase in maximum, average and minimum mouthpiece chamber vacuum, however this effect was not significant between teat length groups.

Milk flow rates of cows with all teats short and all teats long were also examined for the two different liners. The average milk flow rates for each liner and the average effect (treatment – control) is shown below in Table 2.

Table 2. Average milk flow rates of cows with long (4.0 – 6.2 cm, n=3) or short (3.2 - 4.2 cm, n=3) teats with a narrow bore (control) and wide bore (treatment) liner.

Average teat length (cm)	Average flow rate control liner (kg/min)	Average flow rate treatment liner (kg/min)	Liner effect (kg/min) (treatment - control)
5.1[a]	1.9	1.6	-0.3[a]
3.9[b]	2.1	2.7	0.6[b]

[a, b] significant differences within columns.

Significant differences in the liner effect on average flow rates were found between cows with short and long teats.

Our results suggest that milking performance could be improved by applying individual teat cups and milking routines to each teat based on its morphology and milkability. Though not an option with the conventional milking cluster, this application of precision agriculture would be possible with a robotic milker.