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Investigation of the labour and cow production efficiency of side-by-side milking systems

Key external stakeholders: Farmers, Advisory personnel. Milking machine companies

Practical implications for stakeholders:

(i) Increasing the automatic cluster remover (ACR) threshold is an effective strategy to improve milking efficiency (cows milked per operator per hour) in situations where the work routine times of dairy operators can be accelerated.

(ii) Operator efficiency is improved by streamlining the milking preparation routines. Modelling indicated that through the use of a maximum milking time, large improvements in throughput were possible, allowing herd milking duration to be maintained as herd sizes increased.

(iii) Milking operators should seek to limit over-milking to 2 min to minimise changes in teat-end condition. Care is required when sizing milking parlours. When constructing a new swing-over parlour the ideal number of units should be determined based on the anticipated cow milking duration and operator work routine time. In existing parlours, if over-milking is likely to occur then either the work routine may be streamlined by an additional operator in the parlour, ACR installed, applying a maximum milking time or an appropriate number of units deactivated.

Main results:

- When four ACR milk flow rate thresholds (flow rate at which milking cluster is removed from cow) were imposed: 0.2 kg/min, 0.4 kg/min, 0.6 kg/min, and 0.8 kg/min, cluster-on time of the 0.8kg/min cows was 18 to 26% less than that of the 0.2kg/min cows. SCC and milk production variables did not differ between the 4 end-of-milking treatments, despite higher strip yields as the ACR threshold increased.
- Larger herringbone parlors were able to achieve greater throughput, likely through a decrease in operator idle time due to sufficient numbers of clusters to keep the operator fully occupied. Operator efficiency was variable between farms and likely dependent on milking routines in use. Modelling indicated that the use of a maximum milking time could lead to large improvements in cow throughput.
- Over-milking of greater than 2 min resulted in an increase in the teat-end hyperkeratosis score of dairy cows in late lactation. However, over-milking did not affect indicators of udder health (somatic cell count) within the six week period. However, higher teat-end hyperkeratosis scores may have a longer term impact on indicators of udder health if teat-end condition reaches severe levels. Results indicated that to minimize changes in teat-end condition, over-milking should be limited to 2 min, which has implications for milking management in large parlours not fitted with ACRs.

Opportunity / Benefit:

The current study increased the knowledge on the potential milking efficiencies that can be attained. The results have implications for milking management in single-operator swing-over parlours with seasonally calved herds.

Collaborating Institutions:

DairyNZ, Hamilton, New Zealand.

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1. Project background:

A requirement for better work organisation and improved facilities exists on many Irish dairy farms. In order to maintain optimum competitiveness in the long-term, continued technical innovation will be essential. Farmers will have to increase efficiency, enlarge operations or a combination of both. Technological innovations, such as modern milking machines and dairy shed design, have dramatically improved working conditions and reduced labour inputs, enabling one person to manage in excess of 200 cows in New Zealand. Improvements may offer similar potential benefits in Ireland. However, it is vitally important that the correct direction of technological innovation is embarked upon. Heterogeneity in complex farming systems means the strategy of recommending blanket technology packages is not relevant. Thus, it is timely that existing milking operations be revisited in terms of investigating their potential efficiencies.

2. Questions addressed by the project:

(i) Streamlining premilking stimulation routines are effective at reducing cow cluster-on time but are they required to maintain milk yield when increasing the automatic cluster remover (ACR) threshold above 0.4 kg/min.

(ii) To collect and analyse milking data from a sample of commercial farms with swingover herringbone parlours to evaluate milking efficiency over a range of parlour sizes (12-32 milking units).

(iii) To determine the effect of different degrees of overmilking on teat end hyperkeratosis, milk production variables and indicators of udder health during late lactation

3. The experimental studies:

(i) The experiment was arranged as a 3 × 4 factorial: 3 premilking treatments were applied across 4 ACR thresholds. Premilking treatments were as follows: clusters attached directly after cows had walked onto the platform (control); tactile stimulation applied by removing 2 squirts of foremilk from each quarter, requiring ~10 s, followed by immediate cluster attachment (Strip); and mechanical stimulation applied using StimoPuls Apex M (GEA) equipped clusters (Stim). The pulsator ratio was 70:30 with 300 cycles/min (at half vacuum) during stimulation and 60:40 with 60 cycles/min during normal milking. Stimulation time set at 30 s was considered appropriate for cows with a high degree of udder fill, as expected during peak lactation.
For each premilking strategy, 4 ACR thresholds were imposed by the herd management system: 0.2 kg/min (ACR2), 0.4 kg/min (ACR4), 0.6 kg/min (ACR6), and 0.8 kg/min (ACR8). If the cow's milk flow rate remained below the respective threshold level for longer than 4 s, the ACR was activated and the cluster was removed within 5 s. Clusters remained attached for a minimum of 120 s. All treatment groups were balanced for days in milk, cluster-on time, yield, SCC, breed, and age.

(ii) Participating farms were selected for their ability to record milking data and all were equipped with a minimum level of technology including electronic identification of cows, electronic milk metres, automatic cluster removers (ACR) and herd management software that recorded individual milking events. Herringbone parlour sizes ranged from 12 to 32 units (12 units, n = 2; 16 units, n = 1; 18 units, n =3; 20 units, n = 6; 22 units, n = 2; 24 units, n = 3; 30 units, n =1; 32 units, n = 1) and two different parlour manufacturers (DairyMaster, Causeway, Ireland; DeLaval, Tumba, Sweden) were represented. Thirty and 50-degree parlours were included. Data were collected from 22 milking sessions at each of two time points, autumn (October–December 2011; 16 farms) and spring (April–May 2012; 19 farms). Cows were milked twice per day with an average milking interval of 14/10 h. A telephone survey was conducted to collect basic farm details such as herd size, the number of operators in the parlour. The herd management software on each farm was programmed to record similar data fields for each of the two systems. The variables recorded at each milking, according to manufacturer definitions, included cow identification (ID) number, milking date, ID time, cluster attachment time (vacuum on; timestamp hh:mm:ss), row number, unit number, milk yield (kg), milking duration (s; vacuum-on to cluster-off), average milk flow rate (kg/min), and maximum milk flow rate (kg/min).

(iii) The experiment used a randomised design with repeated measures. Four treatments were selected to assess the impact of overmilking on teat-end condition, milking characteristics and indicators of udder health. All treatments were balanced for pre-trial teat-end hyperkeratosis score, herd, lactation number, milking duration, yield, and SCC. Clusters were attached to cows in all treatment groups without pre-milking

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preparation. Clusters were removed automatically by ACR 5s after milk flow rate reached 0.2 kg/min, this treatment was considered the control (Ovr0). The remaining three treatments (Ovr2, Ovr5, and Ovr9) had identical pre-milking procedures to the control, whilst clusters were removed at 120 s, 300 s and 540 s after milk flow rate reached 0.2 kg/min. Cows remained on their allocated treatment for the duration of the six week experiment. Following the experimental period ACR threshold was returned to 0.2 kg/min + 5 s and cows were dried off an average of 3 weeks later. Teat-end hyperkeratosis score was assessed using the field evaluation method (described by Mein *et al.* [National Mastitis Council Symposium 2001, Vancouver, pp. 347–351]), using a 1-4 scale, whereby teats classed as normal (N), smooth (S), rough (R) and very rough (VR) were assigned the scores 1, 2, 3 and 4, respectively. Measurements were taken at four time points, at week 0, week 3, week 5 and week 6. On each occasion all four teats were scored twice by the same assessor, at an AM and PM milking, after cluster removal (within 60 s) and prior to the application of teat sanitizer. The AM and PM scores were then averaged.

4. Main results:

(i) Milk yield was not affected by premilking treatment and no interaction with ACR threshold was detected for any milk production variable. Cows receiving the Strip treatment had a shorter cluster-on time than those on the control treatment ($P < 0.001$), with the scale of the reduction similar at the am and pm sessions, at 13 and 11 s, respectively (3–4%). In contrast, mechanical stimulation (Stim) provided no benefit in reducing cluster-on time compared with the control at both am and pm milkings. Cows on the Strip treatment had a greater average milk flow rate ($P < 0.001$), shorter time from cluster attachment to average milk flow rate ($P < 0.001$), and greater maximum milk flow rate ($P < 0.001$). However, no differences in decline duration were detected between premilking treatments. Furthermore, no differences in SCC, strip yield, or interaction between these measures and ACR threshold were detected. Cluster-on time decreased by 18 to 26% with increasing ACR threshold, for ACR2 and ACR8 treatments ($P < 0.001$). No differences were detected in milk yield, milk composition, SCC, or teat hyperkeratosis score. Only 5 cows developed a new infection during the experiment. Average milk flow rate increased with higher ACR threshold ($P < 0.001$) (Table 1). However, time to average flow, maximum milk flow rate, or milk harvested did not differ in the first 2 min. Decline duration (the time from maximum milk flow rate to the end of milking) decreased with increasing ACR threshold ($P < 0.001$). Cumulative yield was greater ($P < 0.05$) between 135 and 240 s of milking for higher ACR thresholds. Average milk flow rate during early milking, 30 to 45 s, and near peak milk flow, 120 to 135 s, was greater ($P < 0.05$) for higher ACR thresholds. Strip yield increased with higher ACR threshold.

(ii) Cow throughput and milk harvesting efficiency increased with increasing parlour size (12 to 32 units), with throughput ranging from 42 to 129 cows/h and milk harvesting efficiency from 497 to 1430 kg/h (1–2 operators). Greater throughput in larger parlours was associated with a decrease in operator idle time. Operator efficiency was variable across farms and probably dependent on milking routines in use. Both of these require consideration when sizing parlours so high levels of operator efficiency as well as cow throughput can be achieved simultaneously. The mathematical model indicated that application of a maximum milking time within the milking process could improve cow throughput (66% increase in an 18-unit parlour when truncating the milking time of 20% of cows). This indicated that through the use of a maximum milking time large improvements in throughput were possible, allowing herd milking duration to be maintained as herd sizes increase, or capital expenditure minimised.

(iii) Teat-end hyperkeratosis score increased with increasing duration of overmilking at each measurement week (Table 2). The greatest change occurred from week 0 to 3 ($P<0.001$), changes from week 3 to 5 and from weeks 5 to 6 were not significant ($P>0.05$). However, there was an interaction between overmilking treatment and week ($P<0.05$). Mean teat score of the Ovr2 treatment was significantly higher than Ovr0 only at week 5 (Table 2). In comparison, mean teat score of the Ovr5 and Ovr9 treatments were greater than the Ovr0 treatment at week 3, 5 and 6 ($P<0.001$). However, mean teat score of the Ovr9 treatment only increased significantly beyond the Ovr5 treatment at week 6 ($P<0.001$). At week 6 mean teat scores were 0.1, 0.2, 0.4 and 0.6 units higher than week 0 for the Ovr0, Ovr2, Ovr5 and Ovr9 treatments, respectively. Indicators of udder health were not compromised despite the increase in teat-end condition score over the 6 week experiment.

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Table 1. Effect of 4 automatic cluster remover thresholds (ACR2, ACR4, ACR6, and ACR8) on milking characteristics

Variable	Treatment†				SED	P-value
	ACR2	ACR4	ACR6	ACR8		
Average cluster-on time (s)	434	394	386	356	10.51	<0.001
Milk yield (kg)	15.0	14.9	14.8	14.9	0.26	0.83
Average flow rate (kg/min)	2.5	2.6	2.6	2.8	0.07	<0.001
Maximum flow rate (kg/min)	3.7	3.7	3.7	3.8	0.09	0.76
Time to average flow rate (s)	171	161	162	159	9.30	0.60
Milk yield in first 2 min (kg)	4.7	4.7	4.7	4.9	0.14	0.33
Decline duration (s)	121	106	97	78	7.85	<0.001

Treatment: Cluster removed at ACR thresholds of 0.2kg/min, 0.4kg/min, 0.6kg/min, 0.8kg/min

Table 2. Effect of four overmilking treatments (Ovr0, Ovr2, Ovr5 and Ovr9) on mean teat-end hyperkeratosis score (1-4 scale).

	Treatment†					
Time	Ovr0	Ovr2	Ovr5	Ovr9	SED	P-value
Week 0	1.7	1.7	1.7	1.7		
Week 3	1.8	1.9	2.1	2.1	0.07	< 0.001
Week 5	1.7	1.9	2.0	2.1	0.06	< 0.001
Week 6	1.8	1.9	2.1	2.3	0.07	< 0.001

†Treatment: Cluster was removed 5 s (Ovr0), 120 s (Ovr2), 300 s (Ovr5) and 540 s (Ovr9) after milk flow rate reached 0.2 kg/min

5. Opportunity/Benefit:

The process of harvesting milk is a time consuming task on dairy farms. This important task affects all parts of the business from people to cows, milk quality, and capital investment. It is likely that herd sizes will continue to increase, putting pressure on scarce labour resources. Therefore, an efficient milking system is important for farm profitability. Thus the benchmarking of current levels of milking efficiency on commercial dairy farms and identification of factors that influence performance is very important. Developing strategies for reducing the time it takes to milk individual cows and measuring the effects of over-milking on teat-end condition, as completed in this study is also crucial work. Ultimately, modelling these effects to determine their influence on milking efficiency and using the results to evaluate different milking equipment and practices is most worthwhile, to offer the greatest labour saving per euro invested.

6. Dissemination:

Main publications:

O'Brien, B., Jago, J., Edwards, J.P., Lopez-Villalobos, N. and McCoy, F. 2012. Milking parlour size, pre-milking routine and stage of lactation affect efficiency of milking in single-operator herringbone parlours. Journal of Dairy Research, 79:216-223.

Edwards, P., O'Brien, B., Lopez-Villalobos, N. and Jago, J. 2013. Overmilking causes deterioration in teat end condition of dairy cows in late lactation. Journal of Dairy Research, 80:344-348.

Edwards, P., O'Brien, B., Lopez-Villalobos, N. and Jago, J. 2013. Milking efficiency of swing-over herringbone parlours in pasture based dairy systems. Journal of Dairy Research, 80:467-474.

Popular publications:

Edwards, J.P., O'Brien, B., Lopez-Villalobos, N. and Jago, J.G. 2013. Overmilking causes deterioration in teat-end condition of dairy cows in late lactation. In: Agricultural Research Forum, Tullamore Court Hotel, 12-Mar-2013, page 98.

O'Brien, B. 2015. How many cows can one person milk?. Guest contributor to AHI CellCheck Newsletter, June Edition 2015. Page 2. Animal Health Ireland, Carrick-on-Shannon, Co Leitrim. www.animalhealthireland.ie

O'Brien, B. and Upton, J. 2011. Increasing milking efficiency. 'Irish dairying, Planning for 2015' Moorepark '11, Teagasc, Moorepark Open Day booklet.pp 110-112.

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