

ONCE-DAILY MILKING

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ABSTRACT

Once-daily milking of dairy cows for periods of 2 to 12 weeks reduces daily milk yield by 10 to 20%, compared with twice-daily milking, whilst three-times-daily milking will increase yield by about 7%. Concentrations of fat, protein and lactose in milk may show small increases. A number of factors may limit once-daily yield in the short term. Firstly, the presence of an inhibitor in the milk which is effective within a few hours after milking, has been demonstrated by Scottish research. Its effect becomes stronger as the interval since last milking increases. Secondly, udder capacity may also be important. Thirdly, the level of residual milk in the udder affects the subsequent rate of milk secretion and can itself be affected by oxytocin and by the technology and technique of milking.

Research at Ruakura to identify factors associated with tolerance of once-daily milking has studied cows with relatively high concentrations of fat and protein in their milk. These cows were thought capable of producing greater yields of milk solids before udder capacity became limiting. This was not demonstrated within breeds, but Jerseys were more tolerant than Friesians. Other genetic factors yet to be fully evaluated include the ratio of cisternal:alveolar volume of the udder, the level of residual milk and udder capacity. Non-genetic methods for improving yields on once-daily milking could include immunising cows against the inhibitory protein secreted into milk, or treating cows with somatotropin or oxytocin.

INTRODUCTION

Ruakura scientists began to investigate the potential of once-daily milking in the 1980s, despite trends in some countries towards milking three times daily or more. American Holstein cows with relatively low concentrations of fat and protein in their milk may store only 15 to 18 hours of secretion before udder capacity becomes limiting, and may respond to three times daily milking by increasing production. Jersey cows in New Zealand have relatively concentrated milk and may have a better tolerance to an extended milking interval.

The advantages of once-daily milking (Woolford et al., 1985) include improving

the lifestyle opportunities on the family farm, reducing the variable costs of harvesting each litre of milk and perhaps sharing a milking shed between adjacent properties. It could also be a cheaper approach for the individual farmer in the long run than purchasing hardware-dependent robotic milking equipment in the future.

Our objectives at Ruakura are to study physiological, management and genetic factors that will identify or produce cows which show no loss in yields of milk solids when milked once daily, or with a lesser drop in milk value than the costs of the second milking. Research on this subject in New Zealand is at an early stage. This paper will describe some costs and benefits, review some of the factors controlling the tolerance of cows to once-daily milking, compared with twice-daily milked controls, and suggest some factors that could be subjected to genetic or other manipulation to increase once-daily yields of milk solids.

COST BENEFIT TO INDUSTRY

Woolford et al. (1985) estimated the cost savings in a 200-cow herd milked once-daily for the whole season to be NZ\$21 to 24 per milking, or about \$6000 over the whole season. These figures included labour at the minimum New Zealand award rate for agricultural workers (amounting to about 30% of the total costs given above). The real cost of labour to any individual farmer depends of course on whether there is an alternative productive use for the 'spare' labour after once-daily milking. These cost savings need to be balanced against the likely reduced returns. When Woolford calculated the returns 6 years ago, the charge made by the dairy factory for milk volume had not been introduced. On an industry basis, net returns to New Zealand are now thought to be very large, depending on how tolerant we can breed the cows to once-daily milking with high yields of solids. Results of a detailed analysis would also depend, however, on how once-daily milking was achieved. Some different opportunities are described below.

LIMITING FACTORS

The ability of cows to tolerate once-daily milking and still produce high milk yields is determined by a number of factors. As a first approach, the obvious factors to consider are storage capacity of the udder and the rate of water secretion into the udder. Milk solids concentration is also important, if cows are to have a high yield of milk solids.

1. Storage capacity

The effect of milk solids concentration was evaluated at Ruakura using Jersey cows purchased from commercial herds on the basis of being high (HP) or low (LP) in milk protein %, and producing at least 15.5 litres/d at peak milk yield. Data from the purchased cows in the first year of study are shown in Table 1 (Carruthers et al., 1989). The repeatability of protein % from 1987/88 (when

the cows were in commercial herds) to 1988/89 (when in the experiment) was high (0.46). Yields of milk solids were similar in the LP and HP herds, and milk yield was 18% greater in the LP herd. Udder storage capacity (hours worth of milk, as defined by Davis and Hughes, 1988) was 9% greater in HP cows (Table 2). The loss of milk solids on once-daily milking averaged 10 and 12% in HP and LP cows, respectively, compared with a twice-daily control period. Effects on the composition of milk solids were very small. A sample of high ABV Friesians was evaluated in the same experiment (Tables 1 and 2). They produced 30% more milk, containing 16% more fat and protein than LP Jerseys when milked twice daily. Udder capacity in the Friesians was 5% lower than for LP cows, and losses on once-daily milking averaged 15%. Thus, the ability of HP Jersey cows to tolerate once-daily milking was in the direction expected, when compared with LP cows, but the differences were small. They were the result of about two phenotypic standard deviations difference in protein % between herds, the selection intensity being restricted by the lower limit on yield. In addition to the breed difference, there was, however, great variation among cows within a breed in their tolerance of once-daily milking. Per cent loss in milk yield ranged from 3 to 47% at peak lactation and from 0 to 26% in mid/late lactation.

Table 1 Yield (kg/day) and composition of milk for High or Low Protein % Jerseys and for Friesians (November 1988)

Trait	High Jersey	Low Jersey	Friesian
Milk yield	12.7	15.0	19.5
Fat yield	0.84	0.80	0.92
Protein yield	0.55	0.56	0.66
Lactose yield	0.63	0.75	0.95
Fat %	6.61	5.32	4.74
Protein %	4.34	3.72	3.42
Lactose %	4.92	4.99	4.87

2. Physiological Factors

Studies at the Hannah Research Institute in Scotland and summarised by Wilde and Peaker (1990) showed that:

- Increasing the frequency of milking increased daily milk yield,
- Increasing the frequency of milking just one gland in goats increased the daily yield in that gland only, suggesting that a controlling factor was secreted within the gland itself,

The response in daily yield to a shorter milking interval was due to milking out, and not to relief of pressure in the gland. Wilde et al. (1988) showed that there was a locally active chemical inhibitor which decreased milk secretion by negative feedback. The inhibitor was found in a milk fraction containing whey proteins of size 10 to 30 kDa.

The presence of the inhibitor reduced the binding and thus effectiveness of prolactin (Wilde and Peaker, 1990).

It was concluded that the rate of milk secretion depends on the frequency of milking and on the completeness of milk removal, since residual milk (that milk left behind after machine milking) is likely to contain the inhibitor. Carruthers et al. (1989) found that cows which showed high losses when milked once daily tended to be those with high levels of residual milk. It is thought that the higher the percentage of residual milk, the greater is the average age of milk in the udder, and thus the greater the quantity of inhibitor present. Further research is required on whether residual milk is a function of udder characteristics, such as the ratio of cisternal:alveolar volume, or to the cow's responsiveness to oxytocin (Wilde and Peake, 1990).

Carruthers and Copeman (1990) reported that the drop in yield on the first day of once-daily milking has correlated with the subsequent response over a longer period. However, correlations between several once-daily milking periods were low. This suggests that factors which affect response may vary but may be manipulated to minimise losses.

Table 2. Udder storage capacity (hours worth), milk yield (kg/d) with twice-daily milking and subsequent percentage loss of milkfat with once-daily milking of spring calving cows.

Trait	Month	High Jersey	Low Jersey	Friesian
Udder capacity	Oct	27.4	24.8	22.9
	Jan	27.1	25.2	24.4
Milk Yield	Nov	12.7	15.0	19.5
	Feb	9.5	11.0	14.2
% loss	Nov	12.9	14.8	18.2
	Feb	7.5	9.9	11.2

EFFECTS OF ONCE-DAILY MILKING

1. Recovery of yield Recovery of absolute yield after 2 weeks of once-daily milking in groups of cows has been 98 to 100% complete. However, returning to twice-daily milking after 12 weeks of once-daily milking in early lactation left Jerseys producing 16% less and Friesians 21% less than controls milked twice-daily for the whole period. Thus, there was a reduction in litres of udder capacity during the extended once-a-day period (Carruthers and Copeman, 1990), which may also be under the control of a local cell growth inhibitor (Brandt et al., 1988).

2. Recovery of live weight? Experiments at Massey University (Mackenzie et al., 1990) where once-daily milking was started at various times (1, 2 or 3 months before the end of a 9-month lactation) and compared with twice-daily milked controls showed that the greatest weight loss over the 3-month period (18 kg, 4.3%) occurred in the controls. Similar results have been found at Ruakura (Woolford et al., 1985; Carruthers and Copeman, 1990), in cows milked three times every 2 days, or cows milked once daily. Weekly estimates of food intake based on visual assessment of pasture before and after grazing suggested that there was a 7% reduction in intake in the once-daily milked cows (for an 18% reduction in early-lactation yield). Thus, the level of food offered during once-daily milking may need to be optimised for maximal farm benefits. In the Massey experiment, feeding levels of groups during the subsequent dry period were sufficiently high that all groups were of similar weight at calving.

3. Reproduction There is limited evidence of an increased conception rate in cows milked once-daily around the time of mating (Mackenzie et al., 1990). Temporary calf-removal in beef cows increases conception rates (Tervit et al., 1982). There may be a carryover effect of once-daily milking (compared with twice-daily milked controls) on the subsequent conception rate. This was not found in the Massey experiment, possibly because body weight losses had recovered during the dry period.

4. Mastitis The Massey experiment found higher somatic cell counts for the groups on longer periods of once-daily milking. To reduce this may require a degree of learning or change in management, because there are already a few herds in New Zealand using once-daily milking for the whole herd and complete lactations.

POSSIBLE SELECTION CRITERIA

Any udder or milking characteristics found to be associated with a cow's tolerance of once-daily milking would be useful when selecting cows for the industry's contract-mating and breeding schemes. Protein % as a selection criterion was shown to be of limited value in Jersey cows. Volume of residual milk was related positively to loss in yield on once-daily milking but the mechanism by which it affects yields is not fully established. The non-linear

relationship between secretory rate/h and time, particularly over the last 8 h of the 24 h period, is also of interest. A number of factors already measured, such as residual milk and udder capacity, and others including ratio of cisternal:alveolar storage in the udder and sensitivity to oxytocin, may provide better prediction of a cow's response to once-daily milking when the level or activity of the inhibitor is also assessed. Udder volume (which can be obtained from linear measurements of the udder, assuming the shape of a wedge, Davis et al., 1983) increases with interval since milking, and could be an indicator of sensitivity to the inhibitory protein. Hours worth of storage, which is already known to show animal variation, could be an important factor after the effect of the inhibitor has been reduced or switched off. Milk letdown time and maximal milking rate have also been evaluated, but have shown no correlation with the loss on once-daily milking (Carruthers, V.R. and Copeman, P.J.A., unpublished). However, it appears that some udder or milking characteristics have already been changed by selection over the last 30 years, because the udder stripping which was required in early days is no longer necessary.

OTHER APPROACHES

Three other approaches are under consideration. These are immunosuppression of the secretory inhibitor (Wilde and Peaker, 1990), reducing the secretion of lactose into milk (L'Huillier et al., 1989), and supplementing current once-daily yields by treatment with bovine somatotropin (BST) or oxytocin (Carruthers et al., 1991). The latter two methods will be discussed.

As lactose is the main osmotic component of milk, reducing its secretion into the udder would reduce the obligatory volume of water in milk and increase the udder's capacity to store milk solids. Studies using recombinant DNA technology are underway to modify the activity of the enzyme, lactose synthetase, in the pathway from glucose to lactose. BST increases yield in cows milked twice daily by 15 to 25% (Davis et al., 1988). Administration of BST to cows milked once-daily in late lactation increased milk yield by 13% compared with once-daily controls (Carruthers et al., 1991). The use of oxytocin with cows milked once-daily has shown inconsistent results. Yields were restored to those of cows milked twice daily (Woolford, M.W. and Copeman, P.J.A. unpublished), or were not affected (Carruthers et al., 1991). The most likely reason for the difference between the two experiments was the higher dose rate of oxytocin in the former one (20 vs 5 IU).

In conclusion, it appears that milking technology and techniques could be adapted to improve overall farm efficiency using once-daily milking. Further studies are required before optimal combinations of new technology and management are achieved.

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