Automatic milking and milk production recording in New Zealand

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Abstract

Since automatic milking has been proven a viable method of milk harvesting in pasture-based dairying systems, the adoption of automatic milking systems (AMS) has increased in New Zealand (NZ). In contrast to some other countries, the NZ Dairy Herd Testing Standard only allows milk production data for genetic evaluation to be collected from herds that are milked conventionally with fixed milking intervals. Consequently, NZ farmers using AMS (with variable milking intervals per cow) do not receive information on the genetic merit of their cows and are, therefore, unable to make management decisions on this basis. A draft protocol for collecting milk production data on AMS farms was proposed in 2013 and involved the automated collection of milk samples from cows milked during a 48h sampling period. As milking frequency varies on AMS farms, the draft protocol was evaluated on five AMS farms to determine the number of samples per cow collected during 48h and if the duration of sampling could be reduced, while maintaining acceptable accuracy for 24h milk yield estimates. In the current study, 2,879 cow herd tests were analysed. There was considerable variation in the number of milk samples per cow herd test; 4.2, 16.6, 34, 30, 6.7, 4, 2.7, 1.5 and 0.03% of cow herd tests had 1, 2, 3, 4, 5, 6, 7, 8 and 9 milk samples over a 48h sampling period. Twenty-four hour milk yield estimates based on sample periods of 36h and 16h were highly correlated with estimates based on a 48h sampling period (0.99 and 0.97, respectively). However, reducing the sampling period increased the percentage of cow herd tests without any milk samples from 0 (48h) to 0.6% (36h) and 8.0% (16h). In practice, a 48h sampling period is likely to be too expensive. Reducing sampling duration without losing accuracy of 24h milk yield estimates is feasible but the duration should depend on average milking frequency to prevent too many cows not being tested.

Keywords: automatic milking systems, milk recording data, duration of sampling, 24 milk yield

Introduction

Automatic milking systems (AMS) were introduced on commercial farms in 1992 in the Netherlands (Bottema, 1992). The technology was developed for countries with high-input dairying systems, high producing cows, high milk prices, and high labour costs (Lind *et al.*, 2000). Adoption rates were low at first, but this changed from the year 2000 onwards (De

Koning, 2010). Today, it is estimated that more than 10,000 farms worldwide milk their herds automatically (Rodenburg, 2013), with 15-30% of all farms in North-Western Europe using this technology (H. Hogeveen, Wageningen University, the Netherlands, personal communication). Countries with low-input pasture-based dairying systems are also adopting this technology. Automatic milking was introduced into New Zealand with the establishment of the Greenfield project in 2001 (Jago *et al.*, 2002). The main objective of this project was proof of the concept that automatic milking was a viable option for milk harvesting in pasture-based dairying systems. Commercial adoption of automatic milking followed in 2008, with 13 herds being milked automatically by 74 units in the 2012-13 milking season (range: 2-24 units per herd) (J. Jago, DairyNZ Ltd., Hamilton, New Zealand, personal communication). Thus, the adoption of automatic milking is increasing in New Zealand.

In contrast to some other countries where herds are milked automatically, the New Zealand Standard (2007) for dairy herd testing only allows milk production data for genetic evaluation to be collected from herds that are milked conventionally with fixed milking intervals. Additionally, there is no protocol accepted by the New Zealand Standard (2007) that describes how milk recording data should be collected on farms with AMS and how these data should be used to calculate standardised 24h milk yields. New Zealand farmers using AMS (with variable milking intervals per cow) are, thus, unable to submit herd testing information to the national database to estimate genetic merit for milk traits. As a consequence, the accuracy of milk volume, fat, protein and somatic cell score genetic merit of their cows is diminished. This limits their ability to make milk production and milk quality based herd management decisions (e.g. culling decisions).

A draft protocol for herd testing on AMS farms was proposed in 2013 (Jago & Burke, 2013) which involved the automated collection of milk samples from cows during a sampling period of 48h. This draft protocol, however, imposed two problems: firstly, automatic collection of milk samples for 48h is an expensive and time consuming process that may interrupt the daily routine on a dairy farm significantly. Secondly, the proposed protocol was based on data collected solely from the research farm of the Greenfield project, on which the milking frequency averaged just 1.3 times per day (Jago *et al.*, 2004). This milking frequency, however, may not be applicable to milking frequencies of commercial AMS farms in New Zealand.

The objective of the current study was to evaluate the draft protocol on five commercial farms using AMS to determine the number of milk samples per cow collected during a sampling period of 48h and if the duration of the sampling period could be reduced, while maintaining acceptable accuracy for standardised 24h milk yield estimates.

Materials and Methods

Data were collected between December 2011 and February 2013 from five farms located in both the North and South Island of New Zealand. The farms represented a range of New Zealand farm systems, including varying herd sizes, breeds and farm management, including one farm milking a Jersey herd housed during lactation and one pasture-based organic farm. In total, twelve herd tests were conducted, ranging between one and five herd tests per farm

(Table 1). Each herd test was conducted according to the draft protocol (Jago & Burke, 2013), which involved the continuous collection of milk samples of every cow milked by an AMS unit for 48h. Each time a cow was milked by an AMS unit during these 48h, the AMS management system recorded identification numbers of the AMS unit, the automatic milk sampling device and the cow being milking, date and time of milking, date and time of the previous milking of that same cow, milk yield as measured by the (in-line) milk meters installed on each AMS unit, and whether the current milking had been a complete milking (according to the AMS management software).

Table 1. Characteristics of participating farms.

Farm	Herd size (n)	Farm system	Herd tests (n)
1	180	Predominantly pasture fed, organic, spring and autumn calving herds, Friesian-Jersey crossbred herd	5
2	320	Predominantly pasture fed, seasonal calving, Friesian-Jersey crossbred herd	4
3	180[a]	Housed, predominantly silage/TMR fed, spring and autumn calving herds, Holstein-Friesian herd	1
4	500	Housed, predominantly silage/TMR fed, spring and autumn calving herds, Jersey herd	1
5	150	Predominantly pasture fed, seasonal calving, Friesian-Jersey crossbred herd	1

[a] Started with AMS during the 2012/2013 milking season and was expanding herd size to 320

Analyses

Three sampling periods were analysed; the sampling period as proposed by the draft protocol (48h) and two alternative shorter sampling periods (36h and 16h). The first milking for each cow in each sampling period was excluded if the previous milking was incomplete and the last cow milking in the sampling period was excluded if incomplete as recorded by the AMS management software. Only cow milkings with recorded milk yields and corresponding milk composition data within each sampling period were included to calculate the yield per 24h. This resulted in 2,879 cow herd tests for analyses. The procedure for estimating standardised 24h milk yield is based on the description provided by Jago & Burke (2013): From the start of each herd test (n = 12), total milk yield for each cow was calculated by summing all the recorded milk yields of all complete cow milkings of a particular cow for the three sampling periods (16, 36, and 48h). Additionally, the milk interval between current complete and previous complete milking was summed, and recorded as milking interval in days for the same sampling periods of 16, 36 and 48h. The expected standardised 24h milk yield was then calculated by dividing the total milk yield per cow by the total milking interval of that same cow for each of the three sampling periods. As the draft protocol proposes a 48h herd test period, the standardised 24h milk yield estimates from this sampling period were used as a 'gold standard'. Correlation coefficients (r) were calculated for standardised 24h milk yield estimates based on the gold standard and estimates based on sampling periods of 16h or 36h.

Additionally, the proportion of cows without any 24h standardised milk yield estimate during 16, 36, and 48h of sampling was calculated.

Results

The number of milk samples per cow herd test varied between 1 and 9 for a sampling period of 48h (Figure 1). Almost 17% of the cows had two successful milkings during this sampling period. Also, approximately 45% of the cows had >3 successful milkings during this sampling period of 48h (Figure 1).

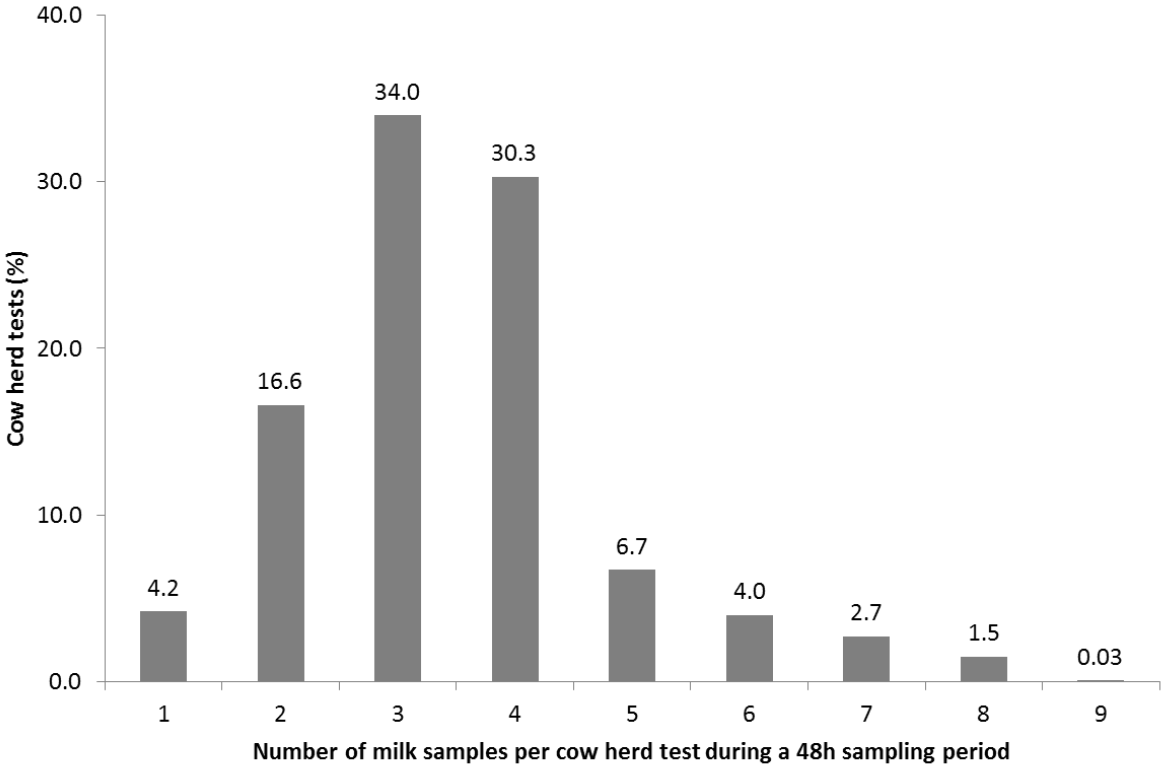

Figure 1. Number of milk samples per cow herd test during a sampling period of 48 hours.

The average milking interval was 14.4h for the twelve herd tests, but this varied from 12.9h to 16.9h (Table 2). There were high correlations between standardised 24h milk yields estimated using a 36h sampling period ($r = 0.994$, range: 0.992-0.998) or a 16h sampling period ($r = 0.971$, range: 0.957-0.986) and the gold standard sampling period (Table 2).

The proportion of cow herd tests without any successful milk sample increased as the length of the sampling period decreased: on average, 0.6% and 8% of the cows had no herd test results when reducing the sampling period to 36h and 16h, respectively (Table 2). For a sampling period of 36h, the proportion of cows missed did not exceed 3% (Table 2). For a 16h sampling period, the proportion of cows missed varied between 3.8% and 14.7% (Table 2).

Table 2. Milking interval during the gold standard sampling period of 48h, and the number of cows tested, correlation coefficients (r) and proportion of cows missed for two alternative sampling periods (36h and 16h) when compared with the gold standard sampling period of 48h. Results are presented per herd test and as average or total.

Herd test	**Milking interval (48h)**	**Sampling period of 36h**			**Sampling period of 16h**		
		Cow herd tests (n)	**r**	**Cows missed (%)**	**Cow herd tests (n)**	**r**	**Cows missed (%)**
1	15.6	171	0.996	0.0	153	0.960	10.5
2	16.9	106	0.997	0.0	98	0.970	7.5
3	14.9	154	0.994	0.0	139	0.975	9.7
4	14.4	156	0.994	0.0	150	0.975	3.8
5	15.4	172	0.995	0.0	163	0.972	5.2
6	13.6	296	0.994	0.0	275	0.957	7.1
7	15.7	309	0.994	0.6	284	0.961	8.7
8	15.4	328	0.992	1.5	284	0.964	14.7
9	12.9	317	0.993	0.3	303	0.973	4.7
10	10.8	194	0.998	0.0	185	0.976	4.6
11	10.9	512	0.993	2.8	486	0.986	7.8
12	16.4	139	0.992	1.4	124	0.979	12.1
Total		**2,854**			**2,644**		
Average	**14.4**		**0.994**	**0.6**		**0.971**	**8.0**

Discussion

The average correlation coefficient between the gold standard and the estimated 24h standardised milk yield values based on a 36h sampling period was high and similar to that reported by Jago & Burke (2013). The average correlation coefficient between the gold standard and the estimated standardised 24h milk yield values based on a sampling period of 16h was lower than the sampling period of 36h, but again similar to that reported by Jago & Burke (2013). This implies that estimations for milk yield became less accurate as the sampling period decreased, but that correlations are still high even for the shortest sampling period of 16h.

The average milking interval in the current study was between the 19h milking interval reported by Jago & Burke (2013) and the 8 to 10h reported by De Koning (2010). This indicates that the AMS farms in the current study had a representative range for milking intervals occurring in practice. Average milking intervals did vary between the five commercial farms (between 10.8h and 16.9h). Moreover, average milking intervals varied within farm, depending on the time of the milking season the herd test was conducted. The variation in average milking interval is strongly correlated with the number of successful milk samples collected per cow: the shorter the milking interval, the higher the proportion of cows with >3 milk successful milk samples per herd test when sampling for 48h as proposed by Jago & Burke (2013). On average, ~45% of the cows had >3 successful milkings. However, the proportion was much higher for herd test 11 (74.6%; results not shown) which also had the shortest milking interval (10.8h).

The ~45% of the cows having >3 successful milkings, on average, during a sampling period of 48h made the proposed protocol of Jago & Burke (2013) too expensive as farmers have to pay for each milk sample analysed. Moreover, while the capture of milk yield is automatic and requires little or no human intervention (Lazenby *et al.*, 2002), herd testing on AMS farms is time consuming and prone to errors as milk samples have to be transferred to a storage facility up to three times a day due to the limited capacity of automatic milk sampling devices (Jago & Burke, 2013). Correlation coefficients reported in the current study suggest that a sampling period of 48h is too long for the majority of cows and that the sampling period could be reduced to 16h without losing too much accuracy of 24h standardised milk yield estimates, irrespective of the average milking interval. This is in line with Lazenby *et al.* (2002) who reported that a sampling period of 14 to 16h would result in a minimal loss of accuracy in estimates for 24h milk yield. However, the critical point will be the proportion of cows without a herd test result. Whereas the proportion of missed cows reported in the current study is <1% for a 36h sampling period (the same as reported by Jago & Burke, 2013), the proportion of missed cows increased to 8%, on average, as the sampling period reduced to 16h. This average of 8% is much lower than the almost 16% of missed cows during the same sampling period reported by Jago & Burke (2013). However, it is concerning that >5% of cows were missed in 75% of the herd tests with a 16h sampling period. Despite the New Zealand Standard (2007) sets no limits for missed cows within a herd test period, future research should focus on finding the optimum trade-off between reducing the duration of the sampling period and minimizing the proportion of cows without herd test results.

The current study reports on 24h standardised milk yields only, whereas milk fat concentration is a far more variable milk parameter than milk yield (Jago & Burke, 2013). Further research should also study the accuracy of standardised 24h yields of fat and crude protein at shorter sampling periods. Additionally, Jago & Burke (2013) reported results for a one-sample herd test protocol and, although no cows were missed during this protocol, the accuracy for standardised 24 milk yield reduced to 0.94. This accuracy is likely to be too low, but other protocols should be investigated, e.g., a protocol where two milk samples are collected.

Conclusion

The current study demonstrated a wide range of milk samples per cow herd test (1 to 9) during 48h of sampling. Additionally, more than 45% of all cows had >3 milk samples collected during this same sampling period. Twenty-four hour milk yield estimates based on 36h and 16h of milk sample collection were highly correlated with estimates based on 48h of sample collection. Reducing the sampling period increased the percentage of cows without any milk sampling results from 0 (48h) to 0.6% (36h) and 8.0% (16h). In conclusion, reducing the sampling period without losing accuracy of 24h milk yield estimates is feasible but the duration of sampling should be adapted based on average milking frequency to prevent too many cow herd tests without 24h milk yield estimates.

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