Limits of error for permanently-installed milk meters used for herd recording or for daily herd management purposes

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Summary

Relaxation of the current ICAR limits for variability in milk yield measurements and for accuracy of fat tests would encourage the development of innovative meter and sampler designs. If milk meters with a maximum bias of 2% for milk yield and maximum Coefficient of Variation (CV) of 7.5% were used for daily measurements, the 305-day milk yields per cow could be estimated with about seven times the precision of any ICAR meter currently approved and used for monthly yield measurements. Such meters would be suitable for daily herd management purposes on many farms and, if these installations were ICAR-approved, they would increase the availability of useful data for progeny testing.

Keywords: milk meter precision, frequency of measurement, 305-d yield.

Marges d'erreur pour les compteurs à lait permanents destinés au suivi du troupeau ou à la gestion quotidienne du troupeau

Un assouplissement des marges pour la variabilité de l'enregistrement de la production laitière et pour la précision du test de matière grasse contribuerait à l'élaboration de conceptions innovantes des compteurs et des échantillonneurs. Si des compteurs à lait qui présentent, pour la production laitière, un écart maximal de 2% et une correction maximale de 7,5% étaient utilisés sur une base quotidienne, l'estimation de la production par vache sur 305 jours pourrait être environ sept fois plus précise que peut l'établir n'importe quel compteur actuellement homologue par l'ICAR qui rend compte de la production laitière sur une base mensuelle. Des compteurs de ce genre conviendraient à beaucoup d'élevages en vue de la gestion quotidienne du troupeau et, si ce type d'installation était homologué par l'ICAR, ils mettraient à la disposition des intéressés plus d'informations utiles aux tests de descendance.

Fehlerabweichungen für fest installierte Milchmengenmessgeräte zur Milchleistungsprüfung oder für das tägliche Herdenmanagement

Eine Lockerung der erlaubten Schwankungsbreite für die Messung von Milchmengen und der Genauigkeit von Fettgehaltsbestimmungen würde die Entwicklung innovativer Messgeräte und Probeziehgeräte fördern. Würden Milchmengenmessgeräte mit einer maximalen Abweichung von 2% für die Milchmenge und 7,5% für den Variationskoeffizienten CV für das tägliche Messen zum Einsatz kommen, so könnten 305-Tage Milchleistungen pro Kuh mit einer 7-fache höheren Genauigkeit angegeben werden, gegenüber derzeitig zugelassener und verwendeter ICAR Milchmengenmessgeräte die für monatliche Milchmengenmessungen verwended werden. Fest installierte Milchmengenmessgeräte würden auf vielen Betrieben das tägliche Herdenmanagement unterstützen. Eine ICAR Zulassung für solche Installationen würde die Verfügbarkeit aussagekräftiger Daten für die Leistungskontrolle erhöhen.

Introduction

ICAR has acknowledged the need to balance the costs of milk recording against the need to maintain an acceptable level of accuracy in data collection. In the ICAR newsletter dated September 1998, it was reported that "Bull proof accuracy can be maintained by increasing the number of daughters in an evaluation, while at the farm level (where individual cow data is required) accuracy could be maintained by more frequent recordings possibly using less accurate equipment". Koorn (1998) concluded that, with increased frequency of measurement of milk yield, it is doubtful that we need the level of accuracy of the current ICAR-approved meters. Although Koorn's prediction of a 90% price reduction for less precise meters seems too optimistic, most manufacturers of milk meters would agree that it is more expensive to make an accurate meter than a less accurate one. Clearly, the costs of manufacturing milk meters to meet the current strict ICAR limits of error have to be passed on to dairy farmers and herd recording associations in the form of higher initial purchase prices and higher maintenance costs. Wilmink et al. (1998) proposed two levels of precision for ICAR-approved meters: "high" for meters with CV less than 2.5%, and "normal" for meters with CV between 5% and 7.5%.

In this paper, we confirm the conclusion that high precision in estimating 305-d yields can be maintained with meters and samplers of lower precision compared with those currently approved by ICAR. In addition, we show that less precise meters can be used successfully for daily herd management purposes.

Prediction of milk yield per lactation

If an ICAR-approved meter is used to collect milk weights on one day per month, the meter contribution to final estimation error is about one half of one percent of the final 305-day lactational yield estimate. This precision of prediction can be maintained with progressively less precise meters if they are used more frequently (Table 1).

Table 1. Meter precision required, if used weekly or daily, to achieve equivalent meter contribution to 305-d yield prediction precision as that currently provided by an ICAR-approved "high accuracy" meter used one day (for two milkings) per month. An average yield of 20L/d split between 2 milkings has been assumed.

	Monthly	Weekly	Daily
Sampling days per 305 d lactation	10	43	305
SE of 305-d yield	34L	34L	34L
Precision (% error) of 305 d yield	0.56%	0.56%	0.56%
Meter precision (CV)	2.5%	5.2%	13.8%

The calculations in Table 1 take account of the meter contribution only. To place this in context, we need to consider the additional contribution to prediction error due to day-to-day biological variation in milk yield.

The average CV of day-to-day milk yield for individual cows, milked under typical Victorian conditions of pasture feeding and seasonal calving, is approximately 7% throughout lactation (unpublished Ellinbank data, calculated within weeks). Assuming a maximum CV of 2.5% for the ICAR-approved meters, then the CV attributable to the day-to-day biological variation in milk yield would be $100*\sqrt{(0.07^2 - 0.025^2/2)} = 6.8\%$.

Table 2. Precision of 305-d yield prediction using meters of varying precision. Calculations are based on a CV of 6.8% for the day-to-day variation in actual yield and an average yield of 20L/d split between 2 milkings.

	Monthly	Weekly	Daily	Daily	Daily
Sampling days per 305 d lactation	10	43	305	305	305
Meter precision (CV)	2.5%	5%	7.5%	14%	54%
SE of 305 d yield	133L	68L	18.5L	34L	133L
Precision (% error) of 305 d yield	2.2%	1.1%	0.3%	0.6%	2.2%

Table 2 shows that despite much lower meter precision, more frequent sampling leads to increased 305 d yield prediction precision. For example, a seven-fold increase in precision of prediction is obtained with daily sampling using a meter having a CV of 7.5% as proposed by Wilmink et al. Presumably, ICAR is confident that monthly measurements made with a meter conforming to the current ICAR-approved limits of error provide an acceptable maximum SE for 305-d milk yield. If so, then it follows logically that daily measurements with a milk meter having a CV of 54% will meet the same standard of acceptable precision.

Simpler meters could be offered to the market at a lower unit price compared with current ICAR-approved meters, thereby improving the potential uptake of herd recording. The lower costs of a 7.5% CV meter would free up resources for additional farm investment in absolutely reliable cow ID, together with a dedicated PC network to store and compare individual cow records.

Limits of error for sub-sampling

Because a 7.5% CV meter used daily would provide a seven-fold increase in the precision of estimating lactational milk yield, fat yield per lactation also would be estimated with greater precision (Clarke & McGowan, 1984), assuming the frequency of sub-sampling is kept constant at once per month.

The current ICAR limit for bias in milkfat measurement is 0.05 percentage units. That is equivalent to a bias of 1.25 percentage units for milk containing 4% fat, or to a bias of 1 percentage units for 5% milk. In other words, the ICAR limit for milkfat bias is roughly twice as stringent as the limit for milk yield bias (2%). This unnecessarily strict ICAR limit means that the results of fat tests effectively dominate the current meter approval process.

The current ICAR limit of 0.05 units of percentage for fat sampling bias could be relaxed to at least +/- 0.1% or, perhaps, to +/- 0.15% with little loss of data integrity from meters used once per month. This relaxation of ICAR limits would help to simplify the design of meters and samplers, thereby further reducing the potential cost of new models.

Daily Herd Management Decisions

The calculations in Tables 1 and 2 deal only with the accuracy of prediction of lactational yield for herd recording, breeding and culling purposes. For daily management purposes, which may involve flagging any cow that is sick or in heat, farmers want to be able to detect a true change in daily milk yield above the normal "noise" in her day-to-day yield. If we assume a CV of 6.8 % as in Table 2, then 95% of the day-to-day variations in milk yield from a typical cow averaging 20 L/day would fall within a range of 17.3 to 22.7 L/day. There

would be no point in trying to detect changes less than about +/- 3 L on a daily basis for herd management purposes.

If a farmer wanted a data management system capable of detecting a drop of 1L/day below this level of "noise", then a milk meter classified as being of "normal" accuracy by Wilmink et al. (1998) would be adequate. Such a meter with a 7.5% CV could detect a change of about 4 L per day because the total CV (including the biological CV of 6.8% would be $100*\sqrt{(0.075^2/2 + 0.068^2)} = 8.6\%$.

These calculations assume that the only means of detecting cows needing attention is by a change in milk weights on a single day. Statistically, about 1% of daily milk weights would be below 16L by chance alone for a cow averaging 20 L/d. The reliability of detecting cows needing special attention could be improved by incorporating one or more correction factors such as:

1) Using the difference from expected yield rather than from average yield per cow.
2) Adding a correction for herd changes to account for weather or paddock effects.
3) Providing exception lists based on individual cow variability rather than a herd average for variability of daily milk yield per cow.
4) Flagging any variations in typical milking order (by recording the time of milking for each cow).

Finally, we question the comment made by Wilmink et al. (1998), that the accuracy of electronic milk meter data used for within-herd management is of no concern to ICAR. Developments in reliable electronic systems for identification of individual cows and for automatic data collection and processing are encouraging many farmers to use their own herd monitoring systems as an alternative to herd recording. This is especially true for larger dairy herds which have greater potential for more accurate, within-herd progeny comparisons. If ICAR could help to guide the approvals process for permanently-installed meters used for daily management purposes (and also qualify the accuracy and reliability of cow ID and data collection systems), these herds would expand the quantity of data available for progeny testing.

References

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