Global 24-hour calculation trends in classical milk recording systems

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Abstract

The ICAR Dairy Cattle Milk Recording WG (DCMR WG) is currently rolling out changes to the dairy cattle milk recording section of the ICAR Guidelines, which were approved in Auckland at the beginning of 2018. The core activities of the group are to improve 24-hour calculations used in classical milk recording and automatic milking systems. It was decided that preparations would be given over in the short term to improving the 24-hour calculations section of the Guidelines: Procedure 1, Section 2 – Computing 24-Hour Yields. Before any changes in the Guidelines, is necessary to monitor and analyse current situation in milk recording organisation, their needs and problems. The DCMRWG invited various organisations from around the world to take part in a survey. Data was obtained from 52 organisations in total. The survey consisted of 90 questions. The survey presents an overview of the current situation and is the basis for all planned changes. As well as monitoring the current situation, the survey aims to establish a future policy and set out recommendations as a way of harmonising practice worldwide. It is also hoped that the survey will serve as a springboard for instigating discussion among milk recording organisations and assessing needs. This was one of the main goals of the project is to strengthen communication and encourage the

exchange of information between working groups and MROs alike. As the survey will deliver aggregated data, practice will be benchmarked for respective organisations to reflect common practice in this field worldwide.

The first part of the study consists of several sections: a general overview, practical experiences with methods recommended in the ICAR Guidelines, problem areas MROs wish to address, priorities and needs, and processes used to estimate coefficients and factors. Some organisations estimate their own factors and coefficients and survey gave an overview on the following areas: number of organisations which estimate own factors and coefficients, problems with estimations, number of animals and herds used for estimations (different indicators used), time period between estimations or recalculations, how cows and herds are chosen, criteria used for selecting herds and cows, data editing and criteria for data exclusion, factors and coefficients used nationally or differences between breeds and regions, estimations and recalculations of conventional methods (not from AMS), what comparisons are used, results from estimations or recalculations (am/pm, method Z, etc.) and the types of statistical indicators used.

The results of the survey should prove invaluable when making changes to the ICAR Guidelines and for benchmarking MROs in a global context, adapting methodologies among organisations where relevant.

Acknowledgements: The ICAR Dairy Cattle Milk Recording WG wishes to thank all of the organisations that took part in the survey.

Introduction

This project analyses trends in 24-hour calculations. The ICAR Dairy Cattle Milk Recording Working Group surveyed ICAR member and non-member organisations in order to summarise and evaluate the needs of milk recording organisations and the challenges faced. Covering all aspects in this area, the survey should be useful as a benchmark for milk recording organisations toward improving their methodologies. It provides an overview on methods recommended in the Guidelines, moving toward a better understanding of all processes and practicalities associated with 24-hour calculations while evaluating the practice of estimating/recalculating factors and coefficients. The analysis should prove invaluable for improving the ICAR Guidelines in this area, namely Procedure 1, Section 2 of the ICAR Guidelines – Computing 24-hour Yields. It is hoped the outcomes of the survey will help inform future practice among MROs.

Materials and methods

The project consists of a survey totalling 90 questions. Data was obtained from 52 organisations from around the world. Countries of origin are shown in Figure 1, with all participants credited as authors of the paper. Data used for the analysis was collected between December 2018 and March 2019.

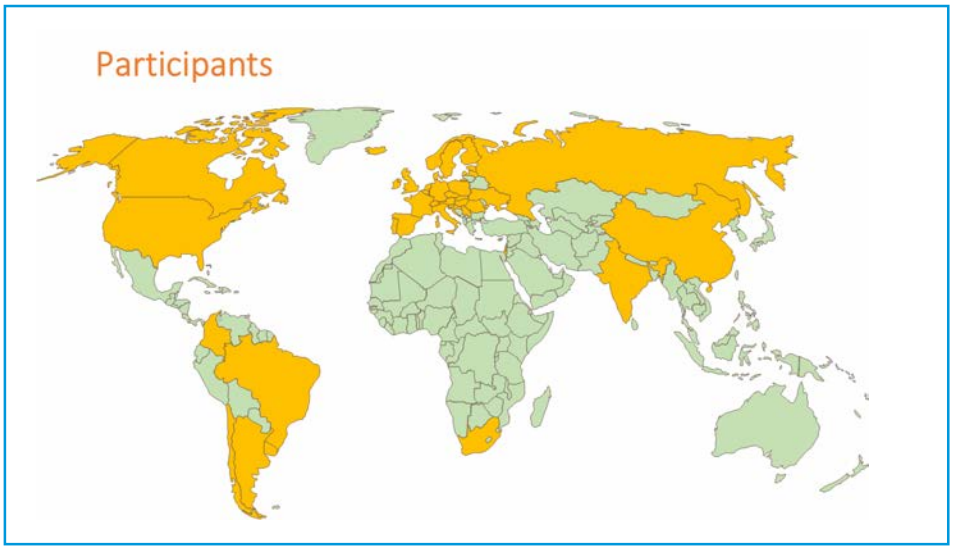

Figure 1. Countries involved in the project

Results – General aspects: 24-hour calculations for classical milk recording systems

Which of the following options does your organisation use for manually operated milkings?

Table 1 shows options for using manually operated milking settings. It is evident that there is a trend toward simplification, with the aim of reducing costs and the overheads, especially for big herds. The standard among organisations is to take one sample. Only seven organisations take more than one milking for both samples. Improving milk recording in big herds (more than 1,000 cows) is a major challenge for the industry. The introduction of new sampling services is required.

Do you use the DELORENZO AND WIGGANGS (1986) METHOD described in the guidelines (see overview document: p 5, Procedure 1, Section 2)?

All information on the DeLorenzo and Wiggans (1986) method is given in Table 2 to Table 6.

Methods in the Guidelines are based on 24-hour calculations. Table 2 shows that this method used 13 organisations and 3 organisations use this method with adaptations. The big advantage of this method is that it is simple and easy to understand and use in principle.

Most of the organisations use factors and coefficients from the Guidelines and some from other countries (Table 3). The problem is that it is difficult to collect data from large data sets, which requires accumulated experience and knowledge. This is probably one of the main reasons why coefficients from the Guidelines are mostly used. Where coefficients and factors are estimated, the recommendation is to use equipment to cover the times of morning and evening milkings.

Table 1. Which of the following options does your organisation use for manually operated milkings?

Answer options	Number of organisations
Complete one-milking recording (milk weight + sample)	35
One-milking sample	21
We always take more than one milking for both samples	7
We only record in AMS	1

Table 2. Do you use the Delorenzo and Wiggangs (1986) method described in the guidelines (see overview document: p 5, Procedure 1, Section 2)?

Answer options	Number of organisations
Yes	13
Yes, but with some adaptations or changes	3

Table 3. What is the origin of the factors you use for this method?

Answer options	Number of organisations
We use factors and coefficients from other countries	2
We use factors and coefficients from the guidelines	11
We use our own factors and coefficients	0

Table 4. Which sampling schemes do you use for this method (see overview document: p 13 and 14, Overview Cattle Milk Recording)?

Answer options	Number of organisations
T	11
C	0
Z	7

Table 5. Which milking frequencies do you use this method for?

Answer options	Number of organisations
2x per day milking	12
3x per day milking	9
4 to 6 per day milking	0

Table 6. How do you define milking times when using this method?

Answer options	Number of organisations
Milking start time on the herd level	12
Middle point of milking time on the herd level	3
Milking start time on the milking group level	1
Middle point of milking time on the milking group level	0
Individual milking start time on the cow level	2

DeLorenzo and Wiggans (1986) is mostly used for methods T and Z. Organisations in the survey do not use this method in the case of method C (Table 4).

Table 5 shows DeLorenzo and Wiggans (1986) is used in for 2 milkings per day and 3 milkings per day, but not for 4 to 6 milkings per day. This is according to the recommendation in the ICAR Guidelines.

Milking times influence accuracy. The survey also analysed how milking times are defined when using the DeLorenzo and Wiggans (1986) method. It will be valuable to add some comments relevant for Table 6 in the new version of the ICAR Guidelines. All organisations use only one option from Table 6 and do not combine them. Most common option in classical milk recording is milking time on the herd level.

Some organisations provided other comments for evaluating their experience:

- We have no scientific studies.
- We have seen a saw teeth effect with AM/PM sampling, This increases with shorter or longer periods between milkings (12 hours for 2X or 8 hours for 3X minimising the saw teeth effect).
- This works well as long as we get accurate times form the dairy farm.
- Works very well on most herds, but there are some problems with 3x herds where am milkings are sampled.
- The present correction still creates a situation where 24-hour fat from evening samples is somewhat higher than from morning samples.
- We have a lot of issues with the calculation of fat (and also SCCs). We get a regular up-and-down fat levels at herd level and the SCC records are not useful.
- I don't think it works particularly well in the case of big herds.
- Our experience is that it works well enough. We compare delivered milk to dairy companies, and the farmer estimates milk consumed or wasted on the farm, amounts which seem to be reasonably correct.
- We have not performed any scientific study of this.
- Useful for 3 milkings. Liu method is not used for 3 milkings.
- It might be valuable to discuss development of the Liu method for 3 milkings. Update Guidelines in this specific case.
- Three milkings should be a discussion item for the ICAR Dairy Cattle Milk Recording WG.

Analysis for three milking based on DeLorenzo and coefficients for this case are available.

Do you use the LIU ET AL. (2000) METHOD describe in the guidelines (see overview document: p10, Procedure 1, Section 2)?

Table 7 shows that the Liu method (2000) is used by 6 organisations, with 3 organisations adapting some equations and 2 making other adaptations. In cases where organisations want to estimate their own coefficients there are insufficient records in some classes. Importantly, new coefficients are estimated for this method, the results of which will be presented at the ICAR Conference in Prague.

The Liu method was used for more sampling schemes (Table 8). It is evident that different practices are used for 24-hour calculation methods. Interestingly, this method is also used for sampling scheme C, a point that should generate discussion on sampling scheme C among the group. Clear recommendations in this field are needed.

The survey also analysed which milking frequencies are used for the Liu method. Most of the organisations use this method in case of 2 milkings per day. Interestingly, 4 organisations used this method in case of 3 milkings per day (Table 9).

The most accurate approach is to define milking times as individual milking start times on the cow level. But this is difficult because it is frequently unavailable in classical milk recording systems (Table 10). The most common option used in milk recording organisations is milking start times on the herd level.

Experiences with using the Liu method are summarised below:

- It can work well, but milking start times are not recorded accurately, so can't be used all the time.
- The Liu method has been used in France since 2011.
- In the French model, we added another class of milking interval.
- Due to changes in milk yield and fat content over the last 15 years, a new model will be established in 2019.
- No problems.
- Very good.
- Will be available for the public.
- A new version will be presented in Prague.
- The ICAR Guidelines will be updated once new coefficients are presented at the ICAR Conference in Prague.

Are there recorded herds where the regular milking intervals do not create a 24-hour recording day?

Some organisations specify that regular milking intervals are not created for a 24-hour recording day (Table 11). This was the case for 5 organisations in less than 10 % of all herds and in 2 organisations in case of more 10 % of all herds (Table 11). This approach can be useful for automatic milking systems and calculations for protein and fat production.

Do you use milk yield data from more than one day when using electronic milk meters (HAND ET AL., 2006) (see Guidelines p 16, Procedure 1, Section 2 - Computing 24-hour Yields)?

There were different situations when using data from more than one day for calculating milk yields with electronic milk meters. In classical milk recording, most organisations use data from one day for calculating 24-hour milk yields (Table 12). This is completely different in comparison with automatic milking systems where the common standard is to use data from multiple numbers of days for calculating 24-hour milk yields. One of the problems when using multiple numbers of days for 24-hour calculations is identification, an issue that needs to be discussed.

The most common method is to add the sampling date to the measurement (Table 13). Excluding the measurement is less common.

Table 7. Do you use the Liu et al. (2000) method described in the guidelines (see overview document: p10, Procedure 1, Section 2)?

Answer options	Number of organisations
Yes	6
Yes but we adapt some equations	3
Yes but we employ adaptations, e.g. different parities, milking intervals and stages of lactation classifications, intercept, slope, different numbers of formulae	2

Table 8. Which sampling schemes do you use this method for (see overview document: p 13 and 14, Overview Cattle Milk Recording)?

Answer options	Number of organisations
Scheme T	10
Scheme C	5
Scheme Z	3

Table 9. Which milking frequencies do you use this method for?

Answer options	Number of organisations
2x per day milking	10
3x per day milking	4
4 to 6x per day milking	0

Table 10. How do you define milking times when using this method?

Answer options	Number of organisations
Milking start time son the herd level	8
Middle point of milking times on the herd level	1
Milking start times on the milking group level	3
Middle point of milking times on the milking group level	0
Individual milking start times on the cow level	1

Table 11. Are there recorded herds where the regular milking intervals do not create a 24-hour recording day?

Answer options	Number of organisations
Yes, less than 10% of all herds	5
Yes, more than 10% of all herds	2

Table 12. Do you use milk yield data from more than one day when using electronic milk meters (Hand et al., 2006) (see guidelines p 16, Procedure 1, Section 2 - Computing 24-hour yields)?

Answer options	Number of organisations
We only use one-day milking data	33
We use data from several days as described in the guidelines	8
We use data from several days but with adaptations	0
We calculate 24-hour yields from a number of days differently	1

Most common standard is to have only one option from the options = listed in Table 12 for the 24-hour period. Combined options (see Table 12) are less common.

Where multiple numbers of days to calculate milk yield production, the common option is 7 days. Organisations using multiple numbers of days are harmonised in this indicator. Only one organisation uses 2 days.

The survey also analysed the connection of milk analysis results with milk yields (Table 14). Half of the organisations used connections between results of milk analysis and the test day and the other half multiple numbers of days. It is recommended to connect data from milk analysis with the test day.

The survey evaluated experiences with Hand et al., 2006. These were the additional comments from some organisations:

- Milk yield is fairly stable at an average of 7 days, with sample components is corrected by milking start times and intervals between milkings. This method should be improved in the future.
- Overall doing well.
- Seems to be OK for management purposes.
- Very limited use, overwhelming use of only test day milk yield.

Do you use other methods not mentioned in the Guidelines?

The survey gave an opportunity to review other methods not recommended in the ICAR Guidelines. There were 4 cases of methods not described in the Guidelines (Table 15) being used. These cases will be discussed, checked and analysed by the ICAR Dairy Cattle Milk Recording Working Group. There were 2 cases in the case of method T, 1 case for milking robots, and 1 case for other cases.

The following comments were provided:

- For calculating 24-hour fat percentages, if there is only one sample available, we use the method described in: *https://doi.org/10.3168/jds.S0022-0302(02)74124-6*
- Canadian AM/PM factors; revised factors in 2016; applies for non-robotic systems
- We note that in Brazil a new regulation has being applied, which stipulates different types of sampling taken with electronic meters
- In France, the Liu method in respect of the T, Z and C schemes is currently used, with Peeters & Galesloot's method used for robots.

Estimating independent factors and coefficients in classical milk recording systems

Results for the independent factors and coefficients in classical milk recording systems summarised in Tables 16 to 24.

Do you estimate your own factors and coefficients?

Most organisations used their own factors and coefficients. The Dairy Cattle Milk Recording Working Group is planning to add a new part to the ICAR Guidelines outlining recommendations for estimations of factors, coefficients, derivations of equations, and a calculation policy.

Table 13. In your measurement period, how do you treat the sampling date?

Answer options	Number of organisations
The sampling date is excluded from the measurement	2
The sampling date is added to the measurement	6

Table 14. How do you connect milk yields with milk analysis results?

Answer options	Number of organisations
With the milk yield from a longer measurement period	4
With the milk yield on the sampling day only	4

Table 15. Do you use other methods not mentioned in the Guidelines?

Answer options	Number of organisations
Yes for sampling scheme T	2
Yes for sampling scheme Z	0
Yes. For sampling scheme C	0
Yes. For milking robots where only one sample is taken (adjusting milk contents from one sample)	1
Yes. For other cases	1

Table 16. Do you estimate your own factors and coefficients?

Answer options	Number of organisations
Yes	20
No	18

Table 17. How long does it take to calculate basic data for estimating/recalculating coefficients?

Answer options	Number of organisations
2-5 years	4
5-10 years	3
Irregularly, as required	3
Within 1 year	2
Over 10 years	2
N/A	1

Table 18. How do you choose herds and/or cows for estimations/recalculations?

Answer options	Number of organisations
All data available	13
Randomly chosen	3
We set our own criteria	5
Statistical analysis	3

Table 19. Do you edit and exclude raw data?

Answer options	Number of organisations
Yes	14
No	3

The following comments point to some issues MROs face when defining formulas, coefficients and factors:

- Poor data collection on milk quality coefficient estimation
- Lack of availability of international consultants with experience in factor development
- Different production systems, i.e. seasonal grazing systems have quite different lactation curves
- Differences between irrigated and unirrigated areas where pasture is the main forage
- We have devised our own formula for predicting 24-hour fat percentages
- Obstacles to deriving factors for converting milk composition from a subsample of a milk recording. For economic reasons, abbreviated sampling is used for a sample from a control day with a dual or triple daily milking regime. Identical and uneven intervals can occur between individual milkings. The major problems are:
    - The relatively high frequency of different variants of non-standard intervals in two or three daily milkings
    - Although same-day intervals typically differ by no more than ± 0.5 hours and are considered equal, it can occur that 3.5 hours are unaccounted for or 10/14 in twice-daily milkings
    - Different milking rates in one herd (part of the herd three times a day, part of the herd twice a day, according to the stage of lactation) for the estimation and practical use of recalculation factors in milk recording
- Milking interval times
- Collecting very large reference data sets (with one sample by am and pm milking) from different breeds to define regression formulas for each breed
- Not yet, we are collecting data.
- Proper participation in different environments and production levels.
- Transfer of data from commercial milking software to certain fields for use in calculations.
- Time and farmers who support the experiment
- Very large reference data set – to define regression formula, breeds, season – most important problem

There was considerable variability among organisations which estimate own factors, coefficients in number of data available. The following data on intervals are for different indicators:

- Number of herds: from 2 to 542. One organisation stated that it varies per breed: different for Holstein and Jersey. One organisation wrote that it is 1-3% of all herds
- Number of cows from 500 to 80,000. One organisation stated Holstein and Jersey breeds differ. One organisation stated 1-3% of all cows.
- The number of milkings also proved highly variable, as previous indicators were between 9,000 and 7,496,476. One organisation used data from 3-6 test days, with another stating figures from 6 to 36 depending on the frequency of the variations of different time intervals between milkings (two to three times a day)

- The number of lactations also varied, with the maximum at 185,600
- Some organisations limit the number of lactations per cow, with 3 or 4 lactations the norm.
- There were also other comments:
    - Coefficients (conversion factors) are used for short-term sampling results (a single milk sample on a control day). The number of cases (herds, cows, milking, lactations) is practically lower the more the intervals there are between milkings, which differs from the same intervals (equal intervals)
    - In France we define the regression formula for the Liu method in 2011 and recalculated and checked the accuracy of the coefficients in 2015
    - We use data as required

The ICAR Dairy Cattle Milk Recording Working Group will add recommendations to the new version of the ICAR Guidelines on minimum and optimum numbers of herds, cows, milkings and lactations. All criteria need be defined.

How long does it take to calculate basic data for estimating/recalculating coefficients?

How do you choose herds and/or cows for estimations/recalculations?

The majority use all available data (Table 18) given the complexity of collecting data for estimating factors and coefficients.

The following criteria were specified:

- Multiple samples per cow over following herd test dates
- Different milking time groups
- Different milking interval groups

Further comments were also added:

- Herd sampling covers all national territories
- We calculate coefficients randomly for half the population and validate them against the other half
- Also different milking interval groups

Do you edit and exclude raw data?

The majority of organisations edit and exclude raw data (Table 19).

Some organisations specify criteria use for data editing and data excluding:

- Completeness of data according to the purpose of the research, outliers detection.
- Few milkings are recorded, lactations started by abortion, long period from calving to first milk recording
- In practice, herds are selected with intervals between milking when estimating factors for the appropriate interval (e.g.14 hours at twice daily milkings or 6 hours, three milkings per day, or the same 12/12 and 8/8/8 intervals). Several control days (months, once a month) are measured (kg, milk), sampled and analysed (% of milk components) for the whole day's milking and all milkings. Reference values

(kg and %) are then calculated from the database. The regression method is used to compute recalculation equations for the whole control day results from one-day milking result according to the length of the interval. This does not apply to the breed milked or their hybrids, nor the order/stage of the lactation. Coefficients are updated approximately after 6 to 10 years. The most important factor (which includes breed, order and lactation stage) is the milking weight (milk yield, kg), included in the form of weight (kg of milk) during reference value calulations (milk, fat, protein, lactose and somatic cell count for the whole control day).

- We use 5 criteria:
  - Permitted range of daily recorded values
  - Records with missing information
  - Days in milk between 7 and 360 days
  - Number of lactation grower than 9
  - Overly large differences in milk yield production between milkings
- Outliers
- Coefficients calculated using BLUES as described by Vollema and Olori
- We exclude milk samples with fat content above 9% or lower than 1.5% and protein above 7% and below 1%.
- Milk yield, fat and protein content

What types of data are excluded?

Excluded data are given in Table 20. The following criteria were given:

- Interval between milkings less than 26 or 6 or 8 hours.
- Interval between milkings greater than 33 or 18 or 16 hours.
- Number of lactations less than 5 or 7.
- Stage of lactation 305 or 360 or 365 days.

Do you use national factors and coefficients?

The majority use national factors and coefficients (Table 21)

Are there any national differences between breeds?

The majority of responses specified no differences (Table 22). Reference data for breeds with small numbers of animals are typically unavailable. One country had reference data for Montbeliarde from an electronic milk meter, estimating coefficients based on milking times at an individual level, which is the best approach.

Table 20. Which data are excluded?

Answer options	Number of organisations
Duplicate records	17
Records with missing information (ID, Lact., Dates, Weights…)	18
Intervals between milkings	3
Overly large differences in milk yield production between milkings	10
Lactation stage (days in milk)	5

Table 21. Do you use national factors and coefficients?

Answer options	Number of organisations
Yes	12
No. We use different factors, coefficients and/or production system for different regions	5

Table 22. Are there any national differences between breeds?

Answer options	Number of organisations
Yes, different factors and coefficients are used for different breeds	5
No	13

Table 23. Where estimations or recalculations of conventional methods (not from AMS) are analysed, what comparisons are used?

Answer options	Number of organisations
A4	10
Different approaches (methods)	1

Table 24. How do you evaluate results from estimations or recalculations (am/pm, method Z…) and which statistical indicators do you use?

Answer options	Number of organisations
Correlation between estimated/predicted daily yields and actual/true daily yields (from reference method, golden standard)	13
Comparison of means, standard deviations and maximum differences (overall, within subgroups)	8
Systematic bias, SD of differences and accuracy (R^2)	6

Where estimations or recalculations of conventional methods (not from AMS) are analysed, what comparisons are used?

With the exception of one organisation, the general consensus is to use comparison method A4 (Table 23) as recommended in the Guidelines and the DCMRWG.

How do you evaluate results from estimations or recalculations (am/pm, method Z...) and which statistical indicators do you use?

The majority of responses indicate a preference for simple indicators. Recommendations in this area will be added to the new version of the ICAR Guidelines. Some organisations combine indicators from more groups (see Table 24).

Conclusion

- Comprising 90 questions, the survey obtained responses from 52 organisations from around the world.
- A trend toward simplifying the milk recording process and reducing the number of samples, especially in big herds, is evident.
- Methods in the ICAR Guidelines are based on 24-hour calculation practice among MROs.
- Precise recording of herd milking times is crucial.
- There are new coefficients for the Liu method.
- In comparison with milking robots results from multiple numbers of days, where they are not commonly used, most organisations use one-day milk recording data. Where not, the time period is mostly 7 days.
- Four organisations stated they used methods not contained in the Guidelines, an area that will be discussed within the DCMR WG.
- The general trend is for MROs to calculate their own factors and coefficients. Calculation policy in this area needs to be addressed.
- Coefficients and factors are regularly recalculated.
- Mostly, all of the available data is used for estimating factors and coefficients.
- Most of the organisations edit and exclude raw data when estimating factors and coefficients.
- Most milk recording organisations that estimate independently use unique factors and coefficients, which also applies to breeds.
- Organisations prefer to use simple statistical indicators .

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