Global 24-hour calculation trends in automatic milking systems

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Abstract

The ICAR Dairy Cattle Milk Recording WG finished its work on the new version of the ICAR Guidelines in February 2018, with the new version approved at the ICAR General Assembly in Auckland. Changes were made to general aspects of cattle milk recording. Over the short term, it was decided that priority be given to improving the 24-hour calculations section of the Guidelines: Procedure 1, Section 2 – Computing 24-Hour Yields. The work comprises several research projects, technical analyses and policy discussions. Central to these efforts, the ICAR Dairy Cattle Milk Recording WG is committed to engaging in discussion with various milk recording organisations and ICAR members working in this sector. To that end, the group is holding a milk recording workshop and technical session at ICAR 2019 in order to stimulate discussion on the types of changes needed in this field.

The ICAR Dairy Cattle Milk Recording WG (DCMRWG) is currently researching current practice toward improving the 24-hour calculations section of the Guidelines: Procedure 1, Section 2 – Computing 24-Hour Yields. Before any changes are made, however, it is vital that the current situation is assessed comprehensively, delving into key aspects related to methodologies, processes, trends and the opinions of milk recording organisations. The DCMRWG conducted a survey of relevant organisations to address these issues, shed light on the level of harmonisation among players, and set a future

direction and strategy on 24-hour calculations for the cattle milk recording sector. One of the goals of the project is to strengthen communication and encourage the exchange of information between working groups and MROs alike. The survey consists of 90 questions and uses solely aggregated data to reflect global practice. Data was obtained from 52 organisations worldwide, giving a representative example of different situations, needs and the specific problems faced.

This part of the project examines the use of automatic milking systems (milking robots) and gauges the general requirements and opinions of milk recording organisations in this area. It considers the impact of automatic milking systems on the milk recording sector, the different options available when milking herds, methodologies (particularly in related to those recommended in the Guidelines), calculation of fat and protein production, impacts of data quality indicators, sampling schemes, and milk yields from multiple numbers of days. The survey reveals how various organisations use their own factors and coefficients, providing information on how they are estimated. It provides information on data collection periods, how animals and herds are chosen for analysis, how are data edited and how organisations work with data before analysis, how factors are used in particular countries (are they unique or specific according to the region and/or breeds, comparison which is used for results, how results are evaluated from estimations or recalculations (method Z, M...) and which statistical indicators are used. A very important part of the project is to establish a future policy and set out practical recommendations for the future.

The results of the survey will prove invaluable when making changes to the ICAR Guidelines. The group wishes to thank all of the organisations that took part in the survey. Central to these efforts, the ICAR Dairy Cattle Milk Recording WG is committed to engaging in discussion with various milk recording organisations and ICAR members working in this sector. Crucially, however, before any changes are made to the Guidelines, the situation among ICAR members and non-members must be assessed. The group is now conducting a detailed overview on methodologies and practical trends in order to gauge opinion and identify the most pressing issues affecting milk recording organisations.

Introduction

The survey is an official project of the Dairy Cattle Milk Recording Working Group comprising two surveys of global milk recording organisations on the topic of 24-hour calculation trends in automatic milking systems and classical milk recording systems. This part of the project summarises the data provided for automatic milking systems (milking robots). The main aim of the project is to use the results to improve Procedure 1, Section 2 of the ICAR Guidelines for Dairy Cattle Milk Recording – Computing 24-Hour Yields. Before any changes are implemented the group decided that the current situation among ICAR member and non-member organisations would need to be monitored and evaluated. The opinions and needs of milk recording organisations as well as the problems they face are detailed here. Covering all aspects of 24-hour calculations in automatic milking system, the survey should provide a benchmark in this field for MROs toward improving their methodologies.

Materials and methods

Data were obtained from 52 organisations from around the world. The participating organisations representing the various countries are listed in Figure 1, with all collaborators credited as authors of the project. Consisting of 90 questions, the survey provides an analysis of all data, which were submitted between December 2018 and

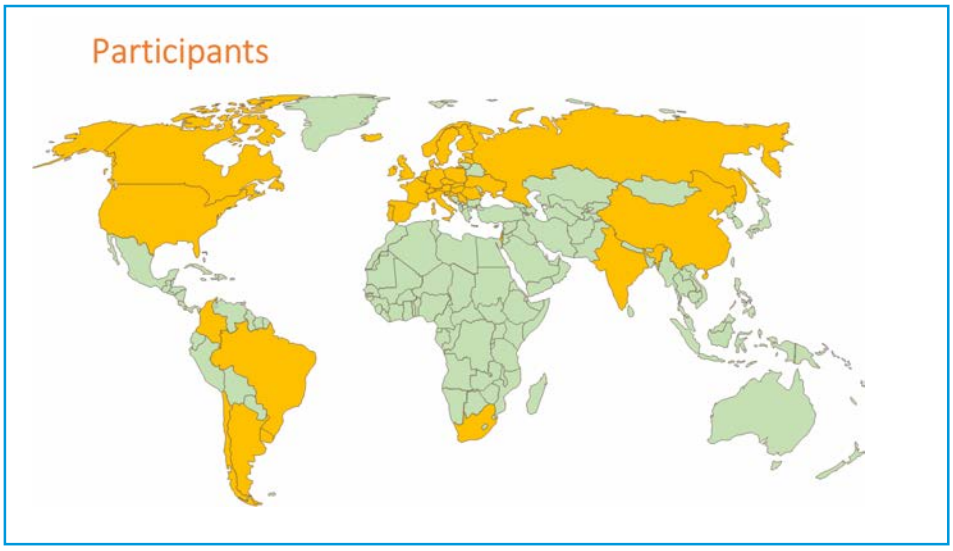

Figure 1. Countries taking part in the project

March 2019. It is expected that the results presented – detailing the different needs, problems and situations faced by MROs – will assist in making improvements to the ICAR Guidelines.

Results: General aspects of 24-hour AMS calculations

Impact of AMS on milk recording

The survey documents the prevalence of automatic milking system use among MROs (Table 1). Figures are compiled based on data provided by 39 organisations, with 13 organisations choosing to skip this question. The number of milking robots has increased, with 28.2% organisations stating that 5 to 20% of their records were AMS-based, 20.5% of organisations stating a share of 20 and 50%, and 7.7% organisations specifying more than a 50% share from AMS. This trend is seeing MROs start to create new services and additional value for customers. Data are also being combined from different sources toward future integration. Harvesting sensor data, simplifying the milk recording process as a whole, and using only one sample for AMS are all key areas to be discussed. At any rate, new services being rolled out by MROs must be reflected in the ICAR Guidelines, a key issue for the Dairy Cattle Milk Recording Working Group.

What recording methods do you use for AMS?

The majority of MROs take milking data from a multiple number of days, mostly including the sample day (Table 2), with only some MROs excluding the sample day. Only seven organisations use data from one day, while, less commonly, four organisations calculate the milk total automatically using robot software. The DCMRWG recommends using raw data calculations from data processing centres as opposed to calculating directly from software. Calculations of data from 4 days are preferred to those taken from just one day.

Table 2 indicates most MROs use one method to calculate AMS milk yields (83.9%), while, for perhaps practical reasons, only 16% combine two as follows:

- Milking data from a multiple number of days + from one day
- Milking data from a multiple number of days + robot software total

Based on responses, milk yields are not taken beyond a period of 7 days, with very few MROs stating they record beyond one week. Most MROs record between 4 and 7 days.

- 2 days: 13.0% of organisations
- 3 days: 4.3% of organisations
- 4 days: 30.4% of organisations
- 5 days: 4.3% of organisations
- 6 days: 4.3% of organisations
- 7 days: 39.1% of organisations

Do you use the Lazenby (2002) method described in the Guidelines

Lazenby (2002) is used by 11 organisations, with 2 organisations used an adaptation of the method (Table 3).

Lazenby (2002) is approved for calculating milk yields over a multiple number of days. The following additional comments were also provided:

- Currently we take into account the last 2 days
- In 2019, we tried to implement a 4-day (96-hour) system
- Overall good
- It is working well
- It seems to work well. We have yet to encounter any problems.
- The method seems to be pretty accurate. We have validated and compared recorded milk with delivered milk to the dairy, with the difference in cases where no cows were missing and calvings were correctly registered coming in at around 1-2%.
- Our experience is that it works well enough! We compared it with milk delivered to dairy companies, where the farmer estimates the milk consumed or wasted on the farm, and consider it reasonably correct.
- We haven't carried out any scientific study of this.

How do you calculate fat and protein yields using AMS?

Fat and protein yields should be calculated on the sampling day (Table 4) based on milk analysis results for that day and milk yield production. There can be discrepancies between test day milk analysis and 24-hour milk yield production, which is calculated over a multiple number of days. Most MROs only use milk yield from the sampling day

Table 1. What is the importance of AMS within your organisation ?

Answer options	Response	
	Number of organisations	Percentage
None of our recorded herds are from AMS	8	20.5
Less than 5% of our records are from AMS	9	23.1
Between 5 and 20% of our records are from AMS	11	28.2
Between 20 and 50% of our records are from AMS	8	20.5
More than 50% of our records are from AMS	3	7.7
Total	**39**	**100.0**

Table 2. What recording methods do you use for AMS?

Answer options	Number of organisations
We use milking data from a multiple number of days, including the sample day	22
We use milking data from a multiple number of days, excluding the sample day	3
We use milking data from one day	7
We use an automatically calculated milk total based on robot software	4

Table 3. Do you use the Lazenby (2002) Method described in the guidelines (see guidelines p 12, Procedure 1, Computing 24-hour yields)?

Answer options	Number of organisations
Yes	11
Yes, but with adaptations	2

Table 4. How do you calculate fat and protein yields using AMS?

Answer options	Number of organisations
We use milk yield from several days, including the sampling day, to calculate the fat and protein yields	13
We use milk yield from several days, excluding the sampling day, to calculate the fat and protein yields	3
We only use milk yield from the sampling day to calculate the fat and protein yields	17

Table 5. What data quality indicators do you monitor when extracting data from the robot software?

Answer options	Number of organisations
Interrupted milkings	11
Data format	13
Milking speed	2
Milk secretion rate	3
Milk yield per milking	22
Milking interval – Missing milkings, 4 hours sampling	12
Recognised data loss	6
Other	4

to calculate fat and protein yields, as recommended by the ICAR Guidelines. Calculations over several days, excluding the sampling day, of fat and protein yields are less accurate. This will again be discussed in advance of the Guidelines.

What data quality indicators do you monitor when extracting data from robot software?

Table 5 shows that MROs mostly use the following quality indicators: milk yield per milking, data format, milking interval and interrupted milkings. The number of combined indicators are summarised in Table 6. Interrupted milking has an influence on fat percentage as do data formats. However, harmonising one format is complicated. The quality of raw data should be accounted for before calculation.

The following comments were provided:

- Comparison to bulk tank
- Milking interval lower than 4 hours. Consistency indicator between consecutive milking for protein % and SCC
- The cow must have a 24-h average from 7 days
- All milking yields for the test day

One indicator is most common (Table 6), but some use more than one indicator. Raw data must be evaluated in advance of 24-hour calculations.

Most indicators are used to exclude individual milkings from data processing (11 organisations). Alternatively, data alerts are generated (5 organisations); seven MROs employ indicators for information purposes only (Table 7).

Checks, data quality and the amount of data available should be reviewed thoroughly.

Below are further comments:

- 24-hour milk production is calculated in comparison with actual/expected milk production.
- For the calculation of expected milk production per minute, the lactation period is divided in parts of 14-days, starting with day 1.
- Expectations per period are made in 3 steps in which wrong milk weighings are detected and neglected for making estimations. A milk weighing can be wrong if the interval is unknown, the deviation is too big compared to surrounding milk weighings, provided the minute-production exceeds the allowed maximum of 70 gr/min, or if the interval exceeds the allowed 1,200 minutes (except for milk recording with just one available milk weighing). In step 1, only milk weighings that meet the roughest criteria of <70 gr/min and < 1,200 minutes interval pass. In step 2, only milk weighings that meet the standard deviation criterion pass. In step 3, only milk weighings deviating only slightly from expected values pass.
- Currently we do not account for: milking intervals under 4 hours, non-consistency between consecutive milkings for protein % and SCC
- We total recorded yields for the test day, and then analyse fat and protein in proportionally mixed samples from the test day

- Milkings with a secretion rate of more than 70g per minute are excluded, as the total yield equates to more than 100kg per day

Do you use the Bouloc et al (2002) method described in the ICAR Guidelines?

This method is designed for calculating milk yield production over one day. Implementation is low with only 5 MROs stating they use the method. Most MROs calculate over a multiple number of days, with one MRO using an adaptation of the method.

What sampling schemes do you use for AMS?

The most common practice is to use scheme Z only (27 MROs), which involves sampling and recording from one milking per cow (Table 8). Prevalence of one-milking sampling has increased with an eye on reducing costs, an important area for future discussion. Schemes E & P that employ all samplings are less common due to the high costs and labour overheads associated with test day preparations. Schemes in which all samples are taken and analysed separately should be used as the golden standard, and represents the most accurate method when using automatic milking systems. Some MROs specified both schemes Z and M are used in cases where the customer prefers higher accuracy (method Z in particular). The industry will need to strike a balance between accuracy and mounting costs going forward. Practice is fairly uniform in this area.

Most MROs use only one sampling scheme for AMS (Table 9). Only a few MROs merge two systems, e.g. Z and M. Merging schemes may particularly benefit herds from which bulls are chosen for artificial insemination, while also aiding management and accuracy.

Do you use the Galesloot and Peeters (2000) method described in the ICAR Guidelines

In cases where only one sample is taken, fat % must be corrected. A total of seven MROs stated they used the Galesloot & Peeters (2000) method (Table 10), with four specifying different methods. A large proportion of MROs do not correct data. The preference is to estimate in-house coefficients, the original Dutch coefficients, or second-generation Dutch coefficients (Table 11).

The DCMRWG recommends correcting fat % to ensure accuracy.

Descriptions of coefficients will need to be updated in the Guidelines.

One-milk sampling and fat corrections are recommended.

Please evaluate how well this method is working in your experience, providing links to any scientific studies you may have conducted:

- Good but we suspect that milking hours should be accounted for
- In France, the Peeters & Galesloot method has been in use since 2018.
- We use the methods established by DRMS
- Customers seem satisfied, but their main interest is SCC

Table 6. Number of combined indicators used by MROs

Number of combined indicators	% of organisations that use combined indicators
1	61.5
2	9.6
3	17.3
4	7.7
5	3.8

Table 7. Do these indicators affect calculations?

Answer options	Number of organisations
No, but they are used for generating user alert messages	5
No, they are only informative	7
Yes, they are used, excluding individual milkings from data processing	11

Table 8. What sampling scheme do you use for AMS?

Answer options	Number of organisations
Scheme Z – sampling from one milking per cow and recording	27
Scheme M – separate samples from several milkings, all analysed separately	6
Scheme E – samples from several milkings joined in equal amounts for analysis	3
Scheme P – samples from several milkings joined proportionally for analysis	2

Table 9. Number of sampling schemes used by MROs

Number of sampling schemes used by MROs	Number of organisations
1	23
2	6
3	1

Table 10 Do you use the Galesloot and Peeters (2000) method described in the guidelines (see overview document: p14, Procedure 1, Computing 24-Hour Yields)?

Answer options	Number of organisations
No, we use a different correction method for one-sample milking	4
No, we use no correction	16
Yes but with adaptations	2
Yes to correct fat content	5

- There is the suggestion that fat percentages tend to be underestimated, especially in cases where sampling starts in the morning.
- Our methods seem to work well though could probably do with improving. That is on the other hand always a question of time and money versus gain.
- Our experience is that it works well enough! We compared it with milk delivered to dairy companies, where the farmer estimates the milk consumed or wasted on the farm, and consider it reasonably correct.
- We have yet to conduct a scientific study in this area.

When analysing several samples or combining them in a non-proportional way, how do you calculate daily fat and protein yields?

Options shown in Table 12 are less common. Most MROs use milk weights to generate a weighted average, as recommended in the Guidelines.

The following comments were provided on various sampling schemes:

- Good
- Where only one fat sample is available, we use the formula described in *https://doi.org/10.3168/jds.S0022-0302(02)74124-6* to calculate the 24-hour fat percentage.
- Indications whether the robot has been successful or not are used for calculations. Samples of non-successful milkings are excluded from calculations.
- No comments
- The method is described in the national guidelines
- *https://infothek.die-milchkontrolle.de/* (ADR-Empfehlung 1.8: MLP AMS)

Sampling schemes M and E are less commonly employed due to high costs. Interval lengths can vary at either 12, 14, or 24 hours (Table 13). In cases where all samples are taken, the sample-taking period can be shortened to decrease costs.

Reducing the sampling period has some advantages, but efforts should be made to ensure enough samples are provided. If it is shortened too much, there is the risk that some cows will go unsampled.

The following additional comments were provided:

- Kg/milk measurements for herds are always based on a period of at least 24 hours or longer for AMS
- The sample taken in herds with automatic milking systems might be shorter than 24 hours. But for all cows at least one sample is taken. The period used for taking samples in a herd during milk recording is often 16 to 20 hours, due to the time needed to transport the equipment from one farm to the other.
- In France, the sampling period is between 12 and 24 hours by robot (for one box), M scheme.

Table 11. What coefficients do you use?

Answer options	Number of organisations
We estimate our own national coefficients	6
We use coefficients from a third organisation	2
We use the original Dutch coefficients	1
We use second-generation Dutch coefficients	3

Table 12. When analysing several samples or combining them in a non-proportional way, how do you calculate daily fat and protein yields?

Answer options	Number of organisations
We use a simple average of all samples analysed	1
We carry out a direct analysis of combined samples	2
We use milk weights to generate a weighted average	5
We use a formula to calculate 24-hour yields from a non-proportionally combined sample	0

Table 13. How long does the sampling period last when using schemes M and E (hours).

Answer options	Number of organisations
12	3
14	1
24	3

Table 14. Over what period do you collect data for estimations or recalculations?

Answer options	Number of organisations
Use one-year data	2
2-5 years	4
5-10 years	2
Irregularly, as required	1
N/A, never	1

Table 15. How are herds and/or cows selected for estimations or recalculations?

Answer options	Number of organisations
All data available	15
Randomly chosen	2
Independently defined criteria	3
Statistical analysis	0
Other criteria	3

Table 16. Do you edit or exclude raw data?

Answer options	Number of organisations
Yes	8
No	2

Results – estimating independent factors and coefficients for AMS

Some organisations estimate their own factors and coefficients, an important topic for the new version of the ICAR Guidelines. Very important will be discussion about minimal number of the animal, herds, etc. which are necessary for accurate estimates (minimal requirements on data).

Survey summarises how many records were used for estimations or recalculations of factors and coefficients. There are differences among MROs that estimate or recalculate their own factors. The following numbers were provided:

- Number of herds from 3 to 13,300
- Number of cows from 360 to 400,000
- Number of milkings 14 to 1,779,324
- Number of lactations 5,000 to 1,200,000

Recommendation in this field could be valuable.

Over what period do you collect data for estimations or recalculations?

Most MROs collect data for estimation or recalculation over a period of 2 to 5 years. Two MROs stated 5 to 10 years, two other over only one year, and one other on an irregular basis (Table 14).

How are herds and/or cows selected for estimations or recalculations?

The most common practice is to select herds and/cows for estimations/recalculations based on all available data (Table 15). = Statistical analysis is not carried out for automatic milking systems.

Do you edit or exclude raw data?

Most MROs edit/exclude raw data when estimating or recalculating coefficients for AMS (Table 16).

Editing raw data is recommended. Two MROs provided the following information:

- Animals with incomplete lactation data from sold, deceased or transferred animals
- We employ the following 5 criteria:
  - Permitted range of daily recorded values
  - Records with missing information
  - Days in milk between 7 and 360 days
  - Milking intervals under 4 hours
  - Number of lactations over 9

Which types of data do you exclude?

Table 17 summarises types of excluded data. Duplicate records or entries with missing information are most commonly excluded.

- Interval between milkings under 4 hours
- Maximal lactation between 5 and 7
- Lactation stage 330 or 360 days

For the number of exclusion criteria applied, see below:

- 1 criterion: 8 organisations
- 2 criteria: 7 organisations
- 3 criteria: 3 organisations
- 4 criteria: 2 organisations

Multiple exclusion criteria are recommended.

Do you use uniform, national factors/ coefficients?

Uniformly applied factors/coeffecients are most common, while those based on regional or production systems are less usual (Table 18).

The same factors are generally used for all breeds. Only two MROs use different factors due to costs and logistics (Table 19).

One MRO stated they collect field data for crossbreed animals as part of a sponsored project.

What type of comparative analysis is used for AMS estimations/ recalculations?

Concerning comparative analysis using AMS, the recommended method of analysing samples separately (24-hour, golden standard) is most common; only two MROs differed in approach (Table 20).

Simple indicators are most commonly applied (Table 21). Clearer definitions of minimum requirements for indicators are required. Some MROs use overly complex indicators.

Table 17. Which types of data do you exclude?

Answer options	Number of organisations
Duplicate records	15
Records with missing information (IDs, lactation figures, dates, weights)	13
Intervals between milkings	2
Excessive differences in milk yield production between milkings	3
Lactation stages (days in milk)	2
Other	4

Table 18. Do you use uniform, national factors/coefficients?

Answer options	Number of organisations
Yes	7
No, based on region/production system	2

Table 19. Are there any differences in factors/coefficients between breeds nationally?

Answer options	Number of organisations
Yes, different factors/coefficients are used	2
No, the same factors/coefficients are used for all breeds	7

Table 20. What type of comparative analysis is used for AMS estimations/recalculations?

Answer options	Number of organisations
All samples are analysed separately (24-hour, golden standard)	4
Different approach	2

Table 21. How do you evaluate results based on estimations/recalculations (method Z, M) 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)	5
Comparison of means, standard deviations and maximum difference (overall, within subgroups)	4
Systematic bias, SD for differences and accuracy (R^2)	2

Who is responsible for developing and implementing new methods?

Most MROs develop and implement new methods themselves, but less commonly in collaboration with research institutes. The following other responses were also provided:

- Ministério Agricultura – Brazil
- Sponsoring agency
- Dairy records providers
- ICAR

Conclusions, recommendations and future policies

- 52 organisations took part in the survey, comprising 90 questions
- A very important part of the project is to establish a future policy and set out practical recommendations for the future
- Impact of AMS on milk recording
    - This trend is seeing MROs start to create new services and additional value for customers
    - Data are also being combined from different sources toward future integration
- As the number of milk recording organisations increases worldwide, customer services need to be improved
- Data is mostly applied based on a multiple number of days for calculating 24-hour milk yields
- Most of the organisations use milk yield from the sampling day to calculate the fat and protein yields which is recommended practice
- Data quality systems are routinely used when handling AMS
- Raw data should always be used
- The prevalence for calculating 24-hour milk yields based on one day has decreased
- The most common practice is to exclusively use scheme Z
- There is a general trend toward simplification with a view to cutting costs
- Fat % should be factored in when taking only one sample, with some MROs stating corrections are not always applied
- Not all MROs estimate their own factors and coefficients
- There is general consensus on the areas in the Guidelines that need to be prioritised

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