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RELIABILITY OF MILK RECORDING DATA UNDER CONDITIONS OF AUTOMATIC MILKING SYSTEM

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Abstract

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Automatic milking system (AMS) brings a change in approach to ensure the data reliability in the official milk recording (MR). The AMS is equipped with flowmeter. AMS software provides the daily milk yield (DMY) and average of the last 7 daily milk yields (AVG7) for MR. Classic MR uses DMY. AVG7 could be more reliable value. Origin of both records (DMY and AVG7) is from AMS flowmeter. The aim of paper was to compare the values of milk yield of cows from daily (DMY) and the extended records (AVG7) from AMS for objective assess of lactations to be used in cattle breeding. Study (2013) with 2 AMS herds (DeLaval and Lely Astronaut): herd 1 – Holstein (H) dairy cows; herd 2 – Czech Fleckvieh (CF) dairy cows. There were following milk records: n = 521 DeLaval (H); n = 567 Lely Astronaut (CF); 70 (H) and 68 (CF) dairy cows. MR samples were analyzed on: fat content; crude protein; somatic cell count. Correlations between AVG7 and DMY were: 0.888 (H); 0.898 (CF, both $P \leq 0.001$). There were insignificant differences ($P > 0.05$; –0.07 ± 3.29 kg for H and 0.28 ± 3.3 kg for CF) between AVG7 and DMY for both robots. The same is valid for differences in the production of milk components. According to this comparison experiment the AVG7 of AMS is a suitable equivalent for the DMY regarding official MR for assessment of lactations.

Keywords: cow, raw milk, milk yield, milk composition

INTRODUCTION

Sophisticated modern approach to cow milking (automatic milking system, AMS) brings a change in approach to ensure the data reliability about milk yield in the official (ICAR, 2008) milk recording (MR).

Many authors were interested in estimations of the total milk yield results and conversions from various sub–options of sampling during milking from methodical point of view (Lee and Wardorp, 1984; Palmer *et al.*, 1994; Lee *et al.*, 1995; Liu *et al.*, 2000; Klopčič *et al.*, 2003; Gantner *et al.*, 2008, 2009; Hanuš *et al.*, 2011, 2012). Multiple daily milking can include regular and irregular intervals, which are often an essential part of the technology process in automated milking systems (Galesloot and Peeters, 2000; Bouloc *et al.*, 2002; Bünger *et al.*, 2002; Lazenby *et al.*, 2002; Amodeo and Tondo, 2006; ICAR, 2008, 2010; Chládek *et al.*, 2009 a, b). The length of the intervals between milkings their regularity or irregularity, such are significant factors in assessing the results of milk composition from individual milk yield (Hargrove, 1994; Ouweltjes, 1998; Weiss *et al.*, 2002; Jovanovac *et al.*, 2005; Hering *et al.*, 2007, 2010; Remond *et al.*, 2009; Jenko *et al.*, 2010).

To measure the yield the AMS is equipped with milk flowmeter. Then, its values are used to assess lactation and subsequently for the genetic improvement of dairy cattle. AMS software provides the sum of milk yields per day as daily milk yield and further the average of the last seven daily milk yields (AVG7) for MR purposes. Classic MR (other

milking equipment as bucket and pipeline (in stable and in milking parlours), more than 99% in the CR) uses milk yield from the control day (DMY, daily milk yield; Hering *et al*., 2005; Lauritsen, 2006) in the official database. However, AVG7 appears to be as more reliable value (AMS) for MR with a reduced influence of random variability in daily milk yield to be used in cattle breeding.

The question arises at AMS whether to use DMY or AVG7 in MR database. In terms of animal breeding the AMS database should be comparable with most records in MR for the objectivity of the assessment of dairy cow lactations. In a situation of origin of both possible milk yield records (DMY and AVG7) from identical AMS flowmeter the higher objectivity for lactation should have AVG7 record. It can be assumed that the lack of significance of differences between DMY and AVG7 and simultaneously high tightness of the relationship between them would justify the possibility of using both variants whereas the official record for MR is DMY. The aim of this study was to compare the values of milk yield of cows from daily (DMY) and the extended variant of records (AVG7) which can enter into MR database from AMS for objective evaluation of lactations of dairy cows.

MATERIAL AND METHODS

Experimental Localities, Milking Robots, Terms of Dairy Herds and Individual Milk Samples

The preparation of this study was based on two herds. These cows are housed in stalls which are equipped with milking robots. The first stable is located in the Central Bohemian Region (49°52'55.111"N, 14°10'3.372"E, altitude 315 m). This is equipped by DeLaval milking robots. There are housed Holstein (H) dairy cows with an average milk yield 10,001 kg (control year 2012–2013) with a fat (F) content of 3.67% (367 kg) and protein (P) content 3.30% (330 kg). The second barn is located in the South Bohemian Region (49°30'8.994"N, 14°23'15.547"E, altitude 556 m) and is equipped with Lely Astronaut robotic device. There are Czech Fleckvieh (CF) dairy cows with an average milk yield 6,180 kg with F content 4.07% (252 kg) and P content 3.57% (221 kg).

The data from Plemdat Benešov from official milk recording as daily milk yield (AMS flowmeter and milk components from laboratory) and calculated averages (AVG7, by AMS flowmeter and software – list of robot data) were used for comparison. Used data came from calendar year 2013. Altogether 40,296 daily milking records (20,440 DeLaval and 19,856 Lely Astronaut) were obtained. These data were selected according to the official MR control days. Data about composition of individual milk samples existed for each record. There were following results of mentioned selection of milk records: n = 520 DeLaval (H); n = 514 Lely Astronaut (CF). In this way there were included 70 (H) and 68 (CF) dairy cows in the evaluation which means equivalent numbers of whole or partial lactations. Each cow had a database from one to ten records (standard lactation) according to reproduction dynamics of herd during the calendar year. Thus the study corresponded to real conditions.

Milk Sample Analyses

Obtained individual milk samples were treated with a preservative D & F Control Microtabs (0.03% bronopol) and transported under cold conditions (< 8 °C) to the laboratory. Samples were analyzed in an accredited laboratory (LRM Buštěhrad, ČMSCH Prague): the fat content (F, %), crude protein (P, %) and somatic cell count (SCC, $10^3.ml^{-1}$). Analyses were carried out using infrared milk analyzer Bentley and fluoro–opto–electronic flow cytometer Somacount (both devices Bentley Instruments, Chaska, USA). These instruments were regularly calibrated according to the reference method results: – extraction by the Röse–Gottlieb method for F; – distillation and titration according to the Kjeldahl method B; – direct microscopy for SCC.

Statistic Treatment of Data from MR Under AMS Conditions

The real presupposition for normal frequency of data distribution is considered at the monitored milk indicators (milk yield, fat and protein) for statistic testing of results. This is valid all the more for their differences. Therefore, the use of paired t–test as one of the parametric tests is justified. Logarithmic data transformation was used only for SCC (Ali and Shook, 1980; Shook, 1982; Raubertas and Shook, 1982; Reneau, 1986; Wiggans and Shook, 1987) because of absence of their normal frequency distribution for individual milk samples (log–normal frequency distribution of values). Consequently, the geometric mean was expressed for SCC.

The results were evaluated for each AMS (breed) and experimental locality separately. Basic statistical indicators as arithmetic mean (x), also the geometric mean (xg) for SCC, standard deviation (sd), variation coefficient (vx) were calculated (Microsoft Excel) in both groups. Linear regression was performed between results of milk yield (AVG7 and DMY). The paired t–test of significance of differences between milk yield means was carried out (AVG7 – DMY) as well.

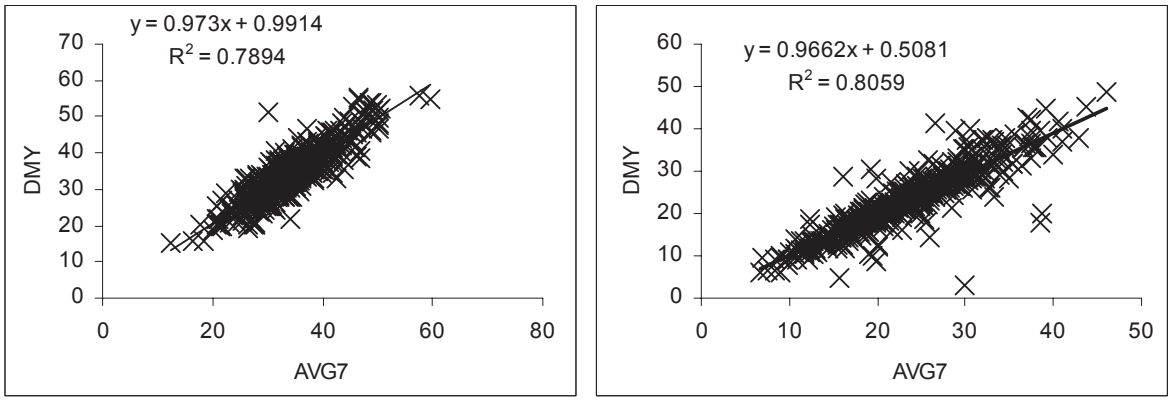
RESULTS AND DISCUSSION

Basic statistical characteristics of milk indicators of yield in files H and CF are given in Tab. I. Variability is comparable between breeds (and also AMSs). The coefficients of variation were: for DMY 20.9 and 19.2%; for AVG7 32.4 and 29.8%. A similar conclusion can be stated for concentration of milk components and also their production (F and P).

I: *Results of the milk yield and composition using AMS in two experimental herds for official milk recording purposes*

AMS	Breed		SCC	log SCC	DMY, 1	AVG7, 2	F	P	F, 1	F, 2	P, 1	P, 2
			$10^3.ml^{-1}$		kg	kg	%	%	kg	kg	kg	kg
DL	H	x	221	1.9724	34.19	34.12	3.82	3.31	1.299	1.294	1.124	1.121
n = 520		xg	94									
		sd	500	0.512	7.16	6.54	0.68	0.33	3.369	3.105	2.241	1.955
		vx (%)	226	25.9	20.9	19.2	17.9	10.0	25.9	24.0	19.9	17.4
LA	CF	x			23.03	23.3	4.08	3.69	0.922	0.932	0.836	0.847
n = 514		sd			7.47	6.94	0.81	0.37	0.3185	0.292	0.246	0.2248
		vx (%)			32.4	29.8	19.7	9.9	34.5	31.3	29.4	26.4

AMS automatic milking system; DL DeLaval; LA Lely Astronaut; H Holstein; CF Czech Fleckvieh; SCC somatic cell count; log SCC $\log_{10}$; DMY daily milk yield; AVG7 average of the last seven daily milk yields; 1 calculation source DMY; 2 calculation source AVG7; F fat; P protein; n number of cases; x arithmetic mean; xg geometric mean; sd standard deviation; vx variation coefficient



r = 0.888*** $P < 0.001$ r = 0.898*** $P < 0.001$

1: *Linear regression relationships between ways of milk yield expression (AVG7 and DMY) in two experimental herds (H and CF) for two AMSs*

AVG7 average of the last seven daily milk yields; DMY daily milk yield; R^2 determination coefficient; r correlation coefficient

SCC geometric mean 94 $10^3.ml^{-1}$ points to the good health of the herd (H). Mentioned result indicates the fact that the study results are not impacted by the state of mammary gland health and thus can be representative.

Linear regression results between the AVG7 and DMY values for the H and CF files are shown in Fig. 1. At the same time these relationships demonstrate possible relations also for fat and protein production (in kg) in MR. Statistically significant correlation coefficients were 0.888 (H, $P < 0.001$) and 0.898 (CF, $P < 0.001$). This means that 78.9 (H) and 80.6% (CF) of variation in the DMY values can be explained by variations in the AVG7 values and vice versa. Higher simmilar correlation (0.981; by Handt *et al.*, 2006) can be explained by its validity for electronical flow milk meter in milking parlour in general as compared to AMS conditions, where the interference of irregular milking frequency and interval is existing.

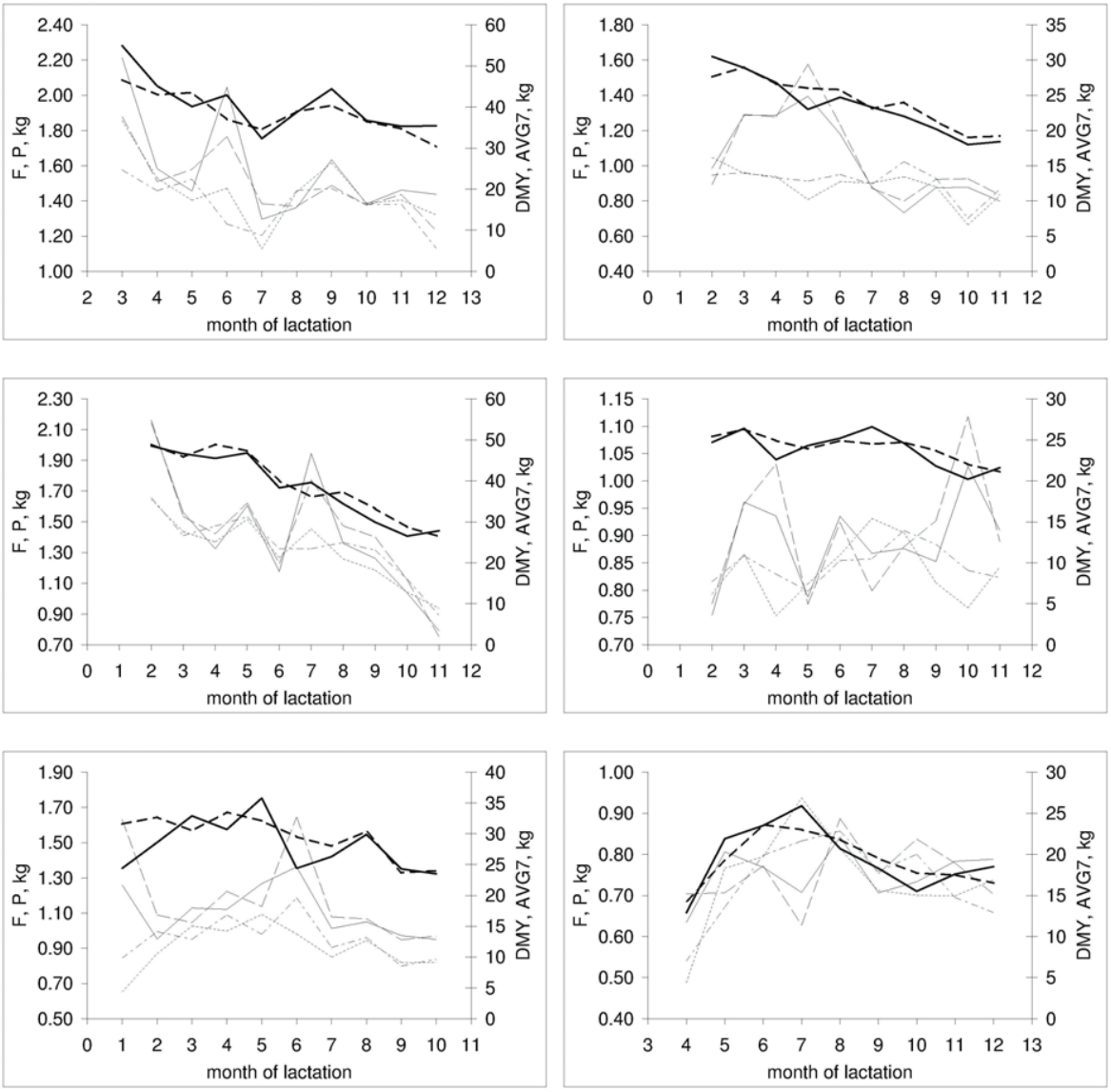
The tests of significance of the differences confirmed (Tab. II) statistically insignificant differences ($P > 0.05$; –0.07 ± 3.29 kg for H and 0.28 ± 3.3 kg for CF) between AVG7 and DMY for H and CF (also for both robots). The same conclusion is valid for the calculated differences in the production of milk components (AVG7 minus DMY) in MR (F and P) in H and CF and also at the both robots. This means that the average milk yield values AVG7 and DMY mutually confirm their reliability and demonstrate a minimum impact of lactation course in the AVG7 case. Therefore, both values can be used in official records of MR according to relevant conditions with this fact that lactation evaluation of dairy cows will not be essentially affected regarding subsequent use of the data in the genetic improvement of milked cattle. However, according to official MR ICAR rules, this is possible to replace the DMY by milk yield average from more days (AVG7) only in MR which is carried out for milk yield in kilograms. Result of measurement of milk composition is valid only for milk yield of relevant control day.

Chládek *et al.* (2011) found higher correlations for the relationships between morning and evening milk yield and daily milk yield (MR, classic twice a day milking) for asymmetric milking intervals (≥ 0.946, $P \leq 0.001$) than were similar correlations

II: *Test results of difference significance (AVG7 – DMY in kg) in two experimental herds and for two AMSs*

Breed	AMS	Difference			
		d	sd	t	significance
H	DL, n = 520	–0.07	3.29	0.48	$P > 0.05$
CF	LA, n = 514	0.28	3.3	1.91	$P > 0.05$

AMS automatic milking system; H Holstein; CF Czech Fleckvieh; DL DeLaval; LA Lely Astronaut; d mean difference; sd standard deviation of d; t value of paired t–test criterion



2: *Demonstration of lactation indicators of selected (higher, medium and lower milk yield) cows by AMS (DL and LA) from both herds (H (left) and CF (right)) for MR purposes*
AMS automatic milking system; DL DeLaval; LA Lely Astronaut; H Holstein; CF Czech Fleckvieh; DMY daily milk yield; AVG7 average of the last seven daily milk yields; MR milk recording. Courses of curves of milk indicators during standard cow lactation: a line full fat DMY; bold dashed line AVG7; thin solid line F 1; thin dashed line F 2; thin dotted line P 1; dash dot thin line P 2; DL (H) position to the left; LA (CF) right; milk yield upper, middle and lower, shifting from top to bottom

(partial to the total value, in AMS) in this work between DMY and AVG7 (0.888 and 0.898, both values $P \leq 0.001$; Fig. 1). Conversely, regarding the comparison of mutual relationships of various types of milk yields at AMS, Wermink *et al.* (2008), Komzáková *et al.* (2008) and Chládek *et al.* (2009 a, b) described more variable correlations for relations of partial milk yields to total milk yield per day according to the length of the milking interval between 0.47 and 0.74. Nevertheless, direct

comparison DMY to AVG7 in AMS is not yet described in the literature.

There are various opinions on use of automatic milking system (AMS, milking robot) in the Czech Republic (CR). Some of them mention the positive contribution of AMS for milk quality and cow health (Dohnal *et al.*, 2011 – a significant reduction in SCC and mastitis occurrence after AMS introduction; Janštová *et al.*, 2011) and effective option to select for abnormal milk (mastitis) according to udder quarters from milk delivery on the market to support the quality of dairy food chain. It is confirmed also by papers from abroad (Klungel *et al.*, 2000 – a reduction in the quality of milk at AMS use, similarly Rasmussen *et al.*, 2002; Litzllachner *et al.*, 2009 – positive reference, similarly Svennersten Sjaunja and Pettersson, 2007). On the other hand there is a view to the high acquisition and maintenance costs in the face of lower–cost human labour in the CR, unlike Germany (Litzllachner *et al.*, 2009). Today, despite of this fact the milking robots are represented in CR dairy system. This implements the need to solve and validate the reliability of data collection for the MR official purposes under AMS conditions.

Therefore, for illustration, there are shown the possible courses of milk yield data in MR (Fig. 2) for selected (higher, medium and lower milk yield for H and CF under conditions of observation) cows during standard lactation as compared on DMY and AVG7 basis (both in AMS). This is possible to see very similar (only a little different) curves of all MR indicators as compared on DMY and AVG7 basis. The mentioned facts warrant previous conclusions.

CONCLUSION

According to the results of this comparison experiment the AVG7 (average seven–day milk yield, AMS flowmeter (kg of milk)) of AMS is a suitable equivalent for the DMY (daily milk yield, AMS flowmeter (kg of milk)) regarding records of milk yield in the official MR for assessment of dairy cow lactations.

SUMMARY

Sophisticated modern approach to cow milking (automatic milking system, AMS) brings a change in approach to ensure the data reliability about milk yield in the official milk recording (MR). To measure the yield the AMS is equipped with milk flowmeter. AMS software provides the sum of milk yields per day as daily milk yield (DMY) and further the average of the last seven daily milk yields (AVG7) for MR purposes. Classic MR uses DMY. However, AVG7 appears to be as more reliable value (AMS) for MR with a reduced influence of random variability in DMY. The question arises at AMS whether to use DMY or AVG7 in MR database. Origin of both possible milk yield records (DMY and AVG7) is from identical AMS flowmeter. The higher objectivity for lactation should have AVG7 record. The lack of significance of differences between DMY and AVG7 and simultaneously high tightness of the relationship between them would justify the possibility of using both variants whereas the official record for MR is DMY. The aim of paper was to compare the values of milk yield of cows from daily (DMY) and the extended variant of records (AVG7) from AMS for objective evaluation of cow lactations to be used in cattle breeding. Study (2013) was based on two herds with AMSs (DeLaval and Lely Astronaut): herd 1 – Holstein (H) dairy cows with an average milk yield 10,001 kg; herd 2 – Czech Fleckvieh (CF) dairy cows with an average milk yield 6,180 kg. The data from Plemdat Benešov from official milk recording as daily milk yield (AMS flowmeter and milk components from laboratory) and calculated averages (AVG7, by AMS flowmeter) were used for experimental comparison. There were following milk records: n = 521 DeLaval (H); n = 567 Lely Astronaut (CF). In this way there were included 70 (H) and 68 (CF) dairy cows. MR samples were analyzed in laboratory Buštěhrad (ČMSCH Prague): the fat content (F, %), crude protein (P, %) and somatic cell count (SCC, $10^3.ml^{-1}$). The results were evaluated for each AMS (breed) and experimental locality separately. Basic statistical indicators were calculated (Microsoft Excel) in both groups. Linear regression was performed between results of milk yield (AVG7 and DMY). The paired t–test of differences between milk yield means was carried out (AVG7 – DMY). Significant correlations between AVG7 and DMY were: 0.888 (H, $P < 0.001$) and 0.898 (CF, $P < 0.001$). This means that 78.9 (H) and 80.6% (CF) of variation in the DMY values can be explained by variations in the AVG7 values and vice versa. There were insignificant differences ($P > 0.05$; –0.07 ± 3.29 kg for H and 0.28 ± 3.3 kg for CF) between AVG7 and DMY for H and CF (also for both robots). The same conclusion is valid for the calculated differences in the production of milk components (AVG7 minus DMY) in MR (F and P) in H and CF and also at the both robots. This means that the average milk yield values AVG7 and DMY mutually confirm their reliability and demonstrate a minimum impact of lactation course in the AVG7 case. Nevertheless, direct comparison DMY to AVG7 in AMS is not yet described in the literature. According to the results of this comparison experiment the AVG7 of AMS is a suitable equivalent for the DMY regarding records of milk yield in the official MR for assessment of dairy cow lactations.

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