Day-to-day Variation of Milk Yield and Milk Constituents

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ABSTRACT

Large day-to-day variations in milk yields bring doubts on the use of single test-day records for various purposes. In Tanzania where milk recording is shifting from daily to less frequent intervals, the magnitude of daily variations has to be evaluated. This study was undertaken to examine daily variations in milk yield and milk constituents.

Three weeks daily (morning and afternoon) milk yields from Uyole and Ihimbu dairy farms were used in this study. In addition, a two weeks sampling for milk composition was conducted at Uyole. Because the data set was orthogonal, the standard factorial analysis of variance was employed. Correlations between daily records of consecutive days were calculated as intra-cow correlations.

Milk yields were significantly ($P < 0.001$) influenced by cow, day of milking and interactions between day and time of milking. Residual standard deviations for milk yields were 1.71 and 0.65 kg for Uyole and Ihimbu, respectively. Corresponding estimates of standard errors of 305-day yields were found to be 165 and 63 kg which were 6.4 and 2.9% of respective herd average lactation yields.

Among milk constituents, protein was the most variable component ($r=0.25$). Intra-class correlations for BF, TS, SNF and ash were all above 0.83. The large variation in protein was ascribed to errors of detemination. It was concluded that acceptable precision in lactation records can be achieved with monthly recording.

INTRODUCTION

Daily recording of milk yield of individual cows is still being practiced in many dairy farms in Tanzania. This is, of course, the most accurate method of estimating lactation milk yield (McDaniel, 1969). Recently some dairy farms have adopted twice or thrice per month milk recording. Everett et al. (1968) and McDaniel (1969) have shown evidence that the accuracy of estimate of lactation yield was dependent upon number and length of test periods. Reliability and accuracy of lactation records estimated by monthly records is determined by variation of individual test-day yields (Erb et al., 1952; Syrstad, 1977). A review by McDaniel (1969) has shown that from monthly tests actual distribution of errors for at least 90% of milk yield estimates were within +/-5% of true production. In a number of studies (Smith and Plowman, 1968; Syrstad, 1977; Mchau et al., 1983) the random component of daily variation has been used to estimate errors of lactation records from monthly records.

Large variation in day-to-day production brings doubts on validity of using test-day results as basis for calculating nutritional requirements of cows (Syrstad, 1977). Further, the random day-to-day variation has to be taken into account when ordinary monthly tests are compared with surprise tests for verification.

Reasons for daily variation in milk yield and composition include completeness of evacuation of milk from the udder (Johansson, 1961; Erb et al.,1952), diseases, underfeeding, being of feed and oestrus or excitement (Schmidt and Van Vleck, 1974). The magnitudes of these variations depend on management procedures, normal physiological changes in the cow, anatomical defects and injuries of the udder.

Considering the fact that in Tanzania we are still debating on recording frequencies in order to minimize recording costs, it is important to assess day-to-day variation of milk yields. This study examines daily variations in milk yield and composition in two large scale dairy farms.

MATERIALS AND METHODS

Milk yield

Daily milk records for the month of October, 1982 for Uyole and May,1989 for Ihimbu dairy farms were used in this study. These were the selected random months. At Uyole, out of the 116 milking cows during the selected month a sample of 45 were chosen while at Ihimbu 35 were chosen out of 46 milking cows. For a cow to be included in the data set, the following had to be fulfilled:

- cows neither calved nor dried off during the month, that is, they were not at the beginning or end of lactation;
- there was no missing morning or afternoon milk yield record through out the month,
- there was no incidence of mastitis or any other sickness.

For the purpose of this study, records from day one to day 21st of the month (three weeks) were used. Uyole cows were mainly Friesians and machine milked using bucket system at 0500 and 1600 hours. Milk was weighed on a spring scale to the nearest tenth of a kilogramme. Ihimbu had Ayrshire cows, hand milked at 0430 and 1630 hours. Milk was measured in the same way as at Uyole.

Since the data set was orthogonal, the standard factorial analysis of variance was employed. The main effects were milking time (morning vs afternoon), cow and day of milking. Milking time was considered as a fixed effect, whereas cow and day of milking were assumed to be random. Because of significant interaction between day x milking time, morning and afternoon milk yields were re-analysed separately for effects of day and cow. Since the number of cow sub-classes was large, the cow effect was absorbed in the analyses and consequently two-way interactions with cow effect could not be included in the model (SAS, 1988). Records were assumed to be described by the following mixed effect model:

$$Y_{ijk} = \mu + D_i + C_j + T_k + DT_{ik} + e_{ijk}$$

where Y_{ijk} = milk yield record from the j^{th} cow milked on the i^{th} day and the k^{th} milking time;
μ = overall mean
D_i = random effect of i^{th} day of milking (i=1,..,21)
C_j = random effect of j^{th} cow (j=1,..,45 for Uyole and j=1,..,35 for Ihimbu)
T_k = fixed effect of k^{th} milking time (1 = morning, 2= afternoon)
DT_{ik}, = two-way interaction as indicated by subscripts
e_{ijk} = random error (N, σ_e^2)

Milk components

This study was conducted at Uyole for 14 days (between 21 April and 4 May,1990) and involved 15 cows. Cows were separated from the main herd and milked first at around 0400 and 1500 hours. All cows had calved between February, 1989 and April, 1990 and at the start of sampling their milk yields ranged between 1.4 and 14.6 kg. Due to shortage of reagents (especially sulphuric acid for protein determination by Kjeldahl method) and manpower, separate analyses for morning and afternoon samples was not possible. Butterfat (BF), protein, total solids (TS), solids-not-fat (SNF) and ash were determined as previously described by Kifaro et al.,1994 from daily composite samples. Milk yield and percentages of milk contents were analysed for random effects of cow and day. Correlations between daily milk yields and percentages of milk components of consecutive days were calculated as intra-cow correlations.

RESULTS

Milk yield

Analysis of both morning and afternoon milk yields in the two farms (Table 1) shows that variations due to cow and day of milking were significant ($P < 0.001$) at Ihimbu and at Uyole. Milking time was an important source of variation ($P < 0.001$) at Uyole but not at Ihimbu. Interaction between milking day and time was significant ($P < 0.001$) at both farms. This necessitated analysing morning and afternoon milk yields separately (Table 2). Both morning and afternoon milk yields were highly ($P< 0.001$) influenced by effects of cow and day. Total daily yields were also significantly influenced ($P < 0.001$) by between cow and day variations.

Means and standard deviations of milk yields for both farms are shown in Table 3. At Uyole cows produced 440 g more milk in the morning than in the afternoon while at Ihimbu the difference was 50 g. Un-adjusted standard deviations for daily milk yields at Uyole and at Ihimbu were 3.03 and 2.35 kg, respectively while corresponding residual standard deviations (within cows) were 1.71 and 0.65 kg (Table 3). Day-to-day variation within cows was, therefore, much higher at Uyole than at Ihimbu.

Table 1: Analyses of variance for milk yield (morning and afternoon) at Uyole and Ihimbu farms.

	Uyole		Ihimbu	
Source of variation[1)]	df	MS	df	MS
Cow	44	67.40 ***	34	54.82 ***
Day	20	4.53 ***	20	1.46 ***
Time (am vs pm)	1	92.05 ***	1	0.67 ns
Day x time	20	13.12 ***	20	0.68 ***
Residual	1804	1.43	1394	0.18

Effect of cow was absorbed in the analysis

Table 2: Analyses of variance of morning and afternoon milk yields (separately) and daily yields for both farms

Farm	Source of variation	df	MS A.M.	P.M.	A.M. + P.M
Uyole	Cow	44	37.64 ***	31.15 ***	134.87 ***
	Day	20	7.45 ***	10.20 ***	9.06 ***
	Residual	880	1.39	1.47	2.91
Ihimbu	Cow	34	26.80 ***	28.16 ***	109.64 ***
	Day	20	0.99 ***	1.15 ***	2.93 ***
	Residual	680	0.18	0.18	0.42

Table 3: Means and standard deviations (within cows across days) of morning and afternoon milk yield

Farm	Variable	Mean	std dev.	CV %
Uyole	Morning milk yield	5.32	1.18	22.18
	Afternoon milk yield	4.88	1.21	24.79
	(am + pm) milk yield	10.20	1.71	16.76
Ihimbu	Morning milk yield	3.94	0.43	10.91
	Afternoon milk yield	3.99	0.42	10.53
	(am + pm) milk yield	7.93	0.65	8.20

Milk constituents

The average daily milk yield and percent composition of milk from the two weeks sampling study at Uyole is presented in Table 4. Table 5 shows the analyses of variance of the variables. Variation between cows was significant for all traits. Effect of day of milking was significant (P < 0.001) for milk yield but not for milk components (P > 0.05).

Within cow correlations between consecutive daily milk yields and components are shown in Table 4. It is important to note that protein content had the poorest repeatability (r=0.25) whereas ash was almost constant from day to day. Intra-cow day-to-day variations in milk yields were higher in Uyole records (r=0.68 and 0.82 for October 1982 and experimental days, respectively) but relatively stable (r=0.92) in Ihimbu records. The within cow standard deviations for milk yield, BF, TS, SNF, protein and ash percentages were 1.51 kg, 0.11, 0.16, 0.14, 0.19 and 0.003 percent units, respectively (Table 4).

Table 4: Un-adjusted means, standard deviations, within cow standard deviations and intra-cow correlations of daily milk yield and milk components from the two weeks sampling study at Uyole

Variable	n	Mean	s.d.	s.d.within cows	intra-cow correlation
Milk yield	182	6.84	3.51	1.51	0.81
BF %	182	3.71	0.25	0.11	0.83
Protein %	182	3.16	0.19	0.16	0.25
TS %	182	12.50	1.15	0.14	0.98
SNF %	182	8.80	1.06	0.19	0.95
Ash %	182	0.75	0.06	0.003	1.00

Table 5: Mean squares from analyses of variance of milk yield and milk components from the two weeks sampling study

	Mean square for:		
Variable	Cow	Day	Residual
d.f.	14	13	182
Milk yield	141.099^{***}	14.450^{***}	2.2775
BF%	0.755^{***}	0.010^{ns}	0.0118
Protein %	0.142^{***}	0.047^{ns}	0.0293
TS%	19.558^{***}	0.012^{ns}	0.0186
SNF%	16.283^{***}	0.017^{ns}	0.0351
Ash%	0.053^{***}	0.000^{ns}	0.0000

DISCUSSION

The significant effect of cow and day of milking on morning, afternoon and total daily milk yields was also reported by Gilbert et al. (1973) and Syrstad (1977). Of particular interest here was the effect of day of milking which has shown that milk yield varied greatly from one day to the other. The higher standard deviation for daily milk yields at Uyole than at Ihimbu is partly attributed to higher milk yields in the former farm (10.20 versus 7.93 kg). While Erb et al.(1952) and Everett et al. (1968) demonstrated that with increasing milk production level daily variations increased, Lindström (1976) attributed the large daily variation in milk yield observed under Kenyan conditions to absolute low level of milk yields. The present results further substantiate the former.

Assuming that the standard deviations of daily records are estimates of random errors of monthly records, then the estimated standard errors of 305-day lactation yield (with 10 recordings; am + pm) can be estimated by the following formula (Syrstad, 1977):

$S_e = O_d$ kg x 305/ 10
where O_d = within cow standard deviation of daily production
Similarly, expected standard error of lactation milk component percentage can be derived as:
S_e units = O_d / 10
Inserting relevant standard deviations into the formula, estimated standard errors of 305-day lactation yields were found to be:
Uyole: 1.71 kg x 305 / √ 10 = 165 kg

Ihimbu: 0.65 kg x 305 / √ 10 = 63 kg

These errors were 6.4 and 2.9% of their respective herd averages (2585 kg for Uyole and 2197 kg for Ihimbu). The error for Ihimbu was much smaller than those reported by Mchau et al.(1983) of 145 kg in Tanzania and by workers in the temperate countries (e.g. Everett et al.,1968 of 119 kg; Syrstad, 1977 of 151 kg). The reason for the small error is likely due to low milk yields coupled with fairly accurate recording of individual yields. Estimated error for Uyole was, on the contrary, very high. Detailed scrutiny of Uyole records revealed that almost all records had even decimal digits (0.2, 0.4, 0.6, 0.8) and 64% had zero as their decimal digit. It was assumed that milk was being weighed to the nearest tenth of a kilogramme but apparently the recording was inaccurate and the recording error contributed to the day-to-day variation. On the other hand, although Ihimbu records had a similar bias, about 23% of records had odd decimal digits suggesting a less biased (more accurate) recording.

Besides milk yield, protein percent had high variation between days from the two weeks study. This is in contrast with findings of Gilbert et al.(1973), Syrstad (1977) and Rook et al. (1992) who found that BF% was more variable from day-to-day than protein percent. The expected standard errors of lactation percentages of BF, protein, TS, SNF and ash were estimated to be 0.03, 0.05, 0.04, 0.06 and 0.009 units, respectively, or 5.6, 0.8, 1.6, 0.3, 0.7 and 1.2% of herd averages. The estimated errors of percentages of milk components are much lower than those reviewed by McDaniel (1969) and those estimated by Syrstad (1977). The reasonable explanation for this low variability is the seriousness given to the sampling in terms of animal handling, accuracy of recording and determinations. This is further confirmed by the high repeatability estimates of percentages of all milk components except protein. The higher day-to-day variation of protein (hence low repeatability of 0.25) can largely be ascribed to errors of determination. The intra-class correlation for milk yield was slightly lower to Lee's (1988) correlation (of 0.96) between test-day and re-test day yields but for BF% he found lower correlations (0.71 to 0.74).

The higher correlation obtained in this work is likely due to the reason mentioned above.

CONCLUSIONS

- Milk yield was more variable from day-to-day at Uyole than at Ihimbu. The difference was attributed to higher milk yields and less accurate recording at Uyole. Acceptable precision of lactation records (errors of < 5%) can be achieved with monthly recording.

- In this study protein percent was the most variable milk component. It was speculated that the result was related mainly to errors in determination. Other milk components had very low day-to-day variations.

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Discussion

Qu: J. Msechu

The author noted that there was differences between Uyole and Ihimbu in the coeffecients of correlation where the Uyole figures were twice those of Ihimbu. What does he think is the reason for this difference?

An: G.C. Kifaro

As mentioned in the presentation, the higher variation at Uyole is attributable to higher milk yield which reflects management level and genetic differences and accuracy of recording milk yield.

Qu: L.A. Mtenga

Day to day variation between the two centres could be, besides milk yield variation and accuracy of recording, due to variation in management, genotypes and milking method. Were these considered in the analysis of the data?

An: G.C. Kifaro

It is true that those factors could influence day-to-day variation of milk yield and composition. However, those factors could not be cross-classified (i.e. occur in both farms), so data was analysed on a within farm basis.