THE ACCURACY OF DIFFERENT WEIGHINGS AND BUTTERFAT TESTING INTERVALS IN TESTING MILK AND BUTTERFAT PRODUCTION

By

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ABSTRACT

This study was designed to determine the accuracy of estimating average yearly milk and butterfat production of the individual cows at recording intervals of 7, 14 and 28 days. The average actual yearly milk production was calculated and compared with the estimated yearly milk production. Average deviations, percent deviations, standard deviations of differences, coefficient of variation and frequency of error have been studied for the different recording intervals.

The differences between the average estimated milk production and the actual milk production were least at the 7-day recording interval and greatest at the 28-day recording interval. The estimated milk production at the 7-day recording interval was slightly higher than the actual milk production while at recording intervals of 14 and 28 days, the estimated milk production was lower. There were only slight differences between the standard deviation of the differences of the estimated milk yields from the actual milk yields at 7 and 14 day testing intervals. The standard deviation of the differences was twice as large at the 28-day testing interval as at the 7-day testing interval. The coefficient of variation was highest for estimated milk

production at the 28-day recording interval. The frequencies of differences between actual and estimated milk yield above 10 percent were zero for 7 and 14-day testing intervals and 1 in 43 for 28-day testing interval.

No significant differences were found between the actual average butterfat percentage and the average estimated butterfat percentage tested at the different intervals. The standard deviation of the differences between the actual and the estimated percent fat was least for the 7-day and highest for the 28-day testing intervals. The frequency of cows with an estimated fat percentage giving an error above 10 percent was zero at 7 and 14-day recording intervals while it was 1 in 8 for the 28-day recording interval.

The estimated fat production for all testing intervals was higher than the actual. The frequency of cows with an estimated fat production record giving an error larger than $\pm$10 percent was 1 in 8 and 1 in 3 at 14 and 28-day testing intervals, respectively.

The results of this study indicate that milk weighings and butterfat testing at 28-day intervals throughout the year will give an accurate estimation of the individual yearly milk and butterfat yields to be used for management and breeding purposes.

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INTRODUCTION

Cows vary from day-to-day in milk and butterfat yields. The most important causes of this variability are irregular feeding, irregular milking intervals and incomplete milking. The greatest accuracy therefore is obtained by daily milk weighings and butterfat testings but in most cases this is prohibitively expensive. A number of sampling intervals have been tried in order to obtain an estimated lactation production with an acceptable degree of accuracy. Most production records in advanced dairy countries are obtained through weighing the milk and testing it for butterfat at approximately monthly intervals. The Dairy Herd Improvement Association (D.H.I.A.) and Herd Improvement Registry (H.I.R.) records are obtained in this manner. Such records are essential for good herd management and effective breeding programs.

By increasing the frequencies of the milk and fat recording, the accuracy and the cost will increase. Since it is essential to keep the cost down, the recording should not be done more often than necessary for securing records of sufficient accuracy. Various workers have attempted to estimate the total yield by recording the milk yield at different intervals ranging from once every three days to once every three months.

With the installation of the milking machine at the Agricultural Research and Education Center of the American University of Beirut, great inconvenience is being felt in recording individual cow's milk because the machine installed does not have a system of automatic weighing. When a cow is milked, the milk pail has to be detached from the machine to have its contents weighed which is time consuming.

As the frequency of milk weighings and butterfat testings increase, the cost of production increases proportionately. Much work has been done to reduce milk production cost largely through a reduction in the cost of feed. However this study was undertaken to determine the accuracy that can be obtained in estimating yearly milk and butterfat production by recording at 7, 14 and 28 day intervals.

By increasing the milk recording and butterfat testing intervals, if sufficient accuracy can be maintained, less labour will be required thus lowering the cost of production.

REVIEW OF LITERATURE

Importance of Records

It is highly desirable to know how to choose the right kind of dairy cow. Records are the best method of evaluating production in any animal. Ascertaining the production of each cow in terms of pounds of milk and butterfat is most important. Milk and butterfat production records of individual cows are essential for efficient dairy husbandry. These records may be thought of as falling into two related categories of use by dairymen, first for the purpose of immediate herd management and second as an estimate of inherent productivity for selection of breeding stock. The individual dairyman probably obtains the major returns from his expenditure for testing through the use of records to adjust his feeding practices and to cull poor producers. Also of great importance is the use of accumulated records for the selection of breeding stock.

Bayley et al. (1952) computed milk and butterfat records for 1255 Holstein Friesian cows in 42 herds for the first 305 days of lactation. The centering method, monthly, bimonthly and quarterly tests were used. The bimonthly and quarterly records were compared with the monthly records. The percent error in milk yield for bimonthly and quarterly records were 3.0 and 5.0, respectively. The average percent

error for fat yield was 4.0 and 6.0 for the two methods, respectively. The frequency of error larger than 10 percent was 1 in 46 for milk yield in bimonthly records and 1 in 8 for quarterly records. Error of this size occurred in the butterfat comparisons at the rate of 1 in 16 for bimonthly records and 1 in 6 for quarterly records. These workers concluded that bimonthly and quarterly records should be satisfactory for sire proving and population studies, but may be unsatisfactory when used to estimate individual records.

Laben et al. (1955) compared the centering day method with the calendar month method using data for one hundred cows (305 day lactation). The calendar month method was found to slightly overestimate records with test dates early in the month and underestimate those with test dates late in the month. The difference in accuracy between the centering method and the calendar month method was not great. It is possible that in practice larger errors may occur with the centering date method than with the calendar month method, due to calculation errors. These workers recommended the calendar month method in preference to the centering method.

Erb et al. (1952) studied the accuracy of different methods of estimating lactation yields. Daily milk production of 19 Holstein cows were weighed and tested for butterfat content throughout the lactation period (305 day lactation). These data were used to compare the relative accuracy

of the following methods of testing (a) calendar month, (b) centering date for 30, 90, 120 and 150-day testing intervals with a 24 and a 96 hour continuous test (c) Herd Improvement Registry and Advanced Registry, using 24 hours testing each month and testing date selected at random from the first, middle and last half of the month and from the entire month. The calendar month method showed twice as much variation as the centering date method, but the former is not likely to be in error more than ±5 percent for fat corrected milk in 25 percent of the records, nor more than ±12 percent in one percent of the records. Herd averages of nine or more cows would not be in error more than ±5 percent of one percent of the time. The centering date on the same basis would show less than half of this amount of variation. The percent error in estimating milk yield greater than 25 percent of the records was 2.4, 3.4, 5.6, 7.4 and 8.8 for the 30, 60, 90, 120 and 150-day testing intervals, respectively. Comparable error for fat yield was 1.2-2.5 percent greater. The effects of 24- to 96-hour testing at each test interval reduced the error less than one percent for milk and less than 2 percent for fat when the 96-hour test was compared with the 24-hour test for each of the testing intervals studied. The accuracy of the 90, 120 and 150-day intervals of testing is grossly influenced by the stage of lactation in which the cow is first tested. The Advanced Registry method of testing (one test per month), which includes a preliminary milking

and reporting of daily milk weights, is on the average only slightly more accurate for estimating fat yield than the Herd Improvement Registry method and is less than one percent more accurate in estimating fat corrected milk yields. Cows that are always tested at the first of the month have the advantage over cows always tested at the end of the month.

Erb et al. (1953) studied causes of variation in fat in 305 day lactation records for 19 cows and 10 day lactation period for 61 cows, where every milking was weighed and tested for butterfat. In addition 2491 D.H.I.A. records were examined. Individual day-to-day variation in butterfat percentage was found to be one percentage unit. Day-to-day variation frequently exceeded 0.2 percent in the pooled milk of the 61 cows. Within any short period of the lactation, milk yield above the average was associated with higher than average butterfat percentages. The butterfat percentage of Holstein cows was maximum at the beginning of the lactation, fell sharply for one and a half months, remained fairly steady for the next three months and slowly increased till the end of the lactation. In Jersey and Guernsey cows however apart from fluctuations in the first month, the fat percent rose steadily throughout the lactation. The month of the year was associated with marked changes in butterfat percent. The effect was greater in the Jersey and Guernsey than in the Holstein cows.

Davey and Alexander (1954) compared actual milk yield of 89 Jersey cows with that estimated from recording at various intervals. The frequency of error larger than ±10 percent was zero for weekly and 1 in 89 for fortnightly. When the monthly recording was adjusted for date of calving, date of cessation of lactation and the amount by which the testing interval differed from 30 days, the frequency was reduced to 1 in 32 for fortnightly and 1 in 5 for monthly recordings. The average percent deviations disregarding signs were 1.6, 2.5, 6.8 and 3.9 for weekly, fortnightly, monthly and adjusted monthly, respectively. Data for 53 animals showed a highly significant difference in butterfat yields calculated from weekly and monthly recordings. The authors concluded that in experimental work with a small number of cows recording interval must not be more than a week to ensure a reasonable degree of accuracy. A larger interval could be tolerated only when a larger number of animals is involved and the figures averaged.

Jardim et al. (1956) compared the accuracy of fortnightly, monthly and bimonthly recordings in a study of 72 lactation periods. The lactations were selected in such a way that each twelve months of calving were represented by lactations from first to the sixth. Average lactation yield as estimated by the three methods was 2460.7, 2466.3 and 2583.0 kilograms, respectively. This was compared with 2468.8 kilograms obtained from daily recordings. On the

basis of statistical analysis of the results, milk recording at bimonthly intervals was not recommended.

Rich and Stoddard (1957) analyzed data that were collected through a newly introduced scheme by the U. S. Department of Agriculture known as the "weigh-a-day-a-month" (WADAM, 1956). Before the introduction of this scheme, out of 20,927,000 cows in U.S.A., 1,406,000 were included in Dairy Herd Improvement Program in which both milk and butterfat production were recorded monthly. In the newly introduced scheme with only milk recording and no butterfat test made, 60,508 cows were registered by June 30, 1957. In this scheme, milk is recorded on or about the 15th day of each month. Comparisons of milk and butterfat records with the "weigh-a-day-a-month" method of 79 Holstein cows showed that essentially the same cows would be eliminated or selected on the basis of the above mentioned two recording methods. It is obvious however that a selection based on high milk yield will favor low fat test.

Smith and Quesenberry (1957) studied data obtained from 177 experimental station herd records for 1954, 1955 and 1956 to compare the actual milk production with the milk yield computed from the milk weights on the 15th of each month. The average monthly difference between the actual and the computed production was less than one pound per day. Significant differences were more common among Jerseys than among Holsteins.

Nayaran *et al.* (1957) compared actual lactational

yields with that estimated by recording at 3, 7, 14 and 21 days for 24 cows of the Red Sindhi, Gir and Ayrshire x Red Sindhi breeds. The average percent error of the calculated yields for the three breeds were 1.4, 1.8, 2.9 and 3.5 for 3, 7, 14 and 21 day testing intervals, respectively. The frequency of error larger than ± 5 percent was considerably less for 3 and 7 day testing intervals than for longer testing intervals.

Fisteag et al. (1958) compared the actual milk production of 462 lactations of Romanian Simmental, Brown Swiss, Pinzgue, Red Dairy and Grey Steppe cows with yields calculated from recording intervals of 15, 21, 30, 42, 60 and 120 days. They concluded that 60 and 120 days recording intervals could be used for a general overall indication of the production of at least 40-50 cows. These workers recommended testing intervals of 30-40 days for individual selection of Simmental and Brown Swiss cows and 15-21 days intervals for Grey Steppe cows. Observations from this research showed that the difference between the actual and the calculated increased with an increase in recording interval. The percent difference was reduced as the level of production increased. The difference was lowest for Simmental and Brown Swiss cows; it was intermediate for Pinzgue and Red Dairy cows; and it was greatest for the Grey Steppe cows. As the difference was affected by type of farm, level of nutrition and breed, these workers recommended to use an interval best suited to local

conditions.

Carre et al. (1959) made a study on the error resulting from periodic sampling during a lactation. Milk production in a herd of Brown Swiss cows was calculated on the basis of actual daily recording of 50 lactations. The actual milk yield was compared with the estimated milk yields with recording intervals of 21, 30, 45, and 60 days. The results were not significantly different. Data on some 2,000 monthly recorded lactations were used to study the accuracy of bimonthly recording. The three chief sources of error were found to be (1) length of interval between calving and first recording, (2) level of milk yield and (3) length of lactation. In considering the method of eliminating these errors it was concluded that the major cause of error in determining performance from periodic sampling lies in the day-to-day variation in milk and butterfat yield. Monthly recording is scarcely frequent enough to be sufficiently accurate to estimate individual performance. A longer recording interval is permissible in estimating group performance. It was further concluded that bimonthly recording seems to be very satisfactory for calculating selection indices for bulls with a large number of progeny.

Jorda (1960) analyzed 50 lactations of Brown Swiss cows recorded daily and 2,000 of Normandy cows recorded monthly by the milk recording syndicate of La-Mancha for studying methods of calculating milk yield. It was concluded

that the accuracy of periodic recording would be increased by taking into account the shape of the lactation curve of individual cows. Monthly recording is sufficiently accurate for individual yields but a longer interval is permissible only in estimating group performance. Bimonthly recording would be satisfactory for calculating selection indices on the progeny of bulls.

O'Cornnor and Lepton (1960) studied the effects of various sampling intervals on the accuracy of estimating lactation yields of milk and solids-not-fat. The basic data consisted of daily milk, fat and solids-not-fat yields for 18 lactations made by 12 dairy Shorthorn cows. Estimates of lactation yield were obtained by using sampling intervals of 7, 14, 28, 42 and 56 days. The milk values were expressed as differences from the actual values. Only in the case of milk was there any significant error in the estimates. The error increased with increasing sampling interval.

Thompson et al. (1960) studied error in estimation of lactation yields of milk and solids-not-fat from individual cows. In this study, individual milkings from 12 Holstein cows were weighed and daily samples were combined and analyzed for fat and solids-not-fat. Both milk yield and composition varied with stage of lactation. The percent fat and total solids in the composite samples were affected significantly by failure to take aliquot samples, but the percentages of solids-not-fat were not affected. Standard error of estimates

for the Babcock test and the Watson Lactometer procedure was ±0.05 and ±0.07 total solids and 0.04 percent solids-not-fat. Bias for the Watson Lactometer procedure over the whole lactation was -0.02 percent total solids. The bias changed with stage of lactation. The large and small model Watson Lactometer gave results that did not differ significantly. Sampling error for lactation yields of milk, fat and solids-not-fat was 273, 13, and 26 pounds, respectively. When expressed as coefficient of variation, the sampling error for fat and solids-not-fat yields did not differ significantly. The monthly sampling procedure used in Dairy Herd Improvement Associations gave unbiased estimates for yields of milk, fat and solids-not-fat.

Nagy (1962) analyzed milk records of 310 Hungarian Spotted cows. This study showed that the difference between the actual and the estimated milk yield was less than 6 percent for 95 percent of the cows recorded monthly and less than 6 percent for 80 percent for those recorded bimonthly. A deviation of 10 percent was found in the records of 3 percent of the cows and only 2 percent of the records deviated more than 10 percent.

Krempa and Krempa (1962) studied the difference between the daily recorded milk production of 92 cows with that of the results of the milk recording at different intervals. The daily recording of milk and butterfat percentage was compared with fortnightly and monthly. It was found that

the routine monthly recording gave on the average a milk yield higher than the actual quantity as measured by daily tests. The estimated average fat percentage was lower when recording was done once a month than twice a month. Twice a month recording is regarded by the authors as being sufficiently accurate for lactation purposes.

Youssef et al. (1962) working with buffaloes found that the differences between the actual and the estimated milk yields decreased as the milk yield increased and increased as the interval of recording increased. The coefficient of variation when signs were ignored was 1.22, 1.56 and 2.47 for recording once in every 7 days, once in every 14 days and once in every 28 days, respectively. The average differences between recording one day every week and one day every four weeks were less than 50 pounds for a lactation yield of 4,000 pounds. The frequency of error larger than ± 5 percent of the actual yield is 1 in 56, 1 in 16 and 1 in 9 for recording one day in every one, two and four weeks, respectively. The error in recording one day in every fourteen days differed by 0.34 percent from recording one day in every week. The difference between recording one day every four weeks and one day every week was 1.25 percent. This does not amount to more than 50 pounds of milk with a yield of 4,000 pounds. The average milk production of individual cows in this study was less than 4,000 pounds. These workers concluded that recording the milk production of

buffaloes one day every four weeks throughout the lactation gave a sufficiently accurate estimate of the milk yield for practical purposes, as it differed only by 2.47 percent from daily recordings.

MATERIALS AND METHODS

Milk Production

Forty-three yearly milk production records were available for this study (table 1). These records were completed at the Agricultural Research and Education Center of the American University of Beirut, during the year 1958-1963.

Criterion used for selection of yearly production data of a particular cow were (1) the cow selected must have remained in the herd for 365 days (2) the cow must have had milk production data for at least 224 days of that year and (3) the cow should not have had nursed a calf. The lactation periods studied ranged from 224-365 days with an average of 305 days. The cows were hand milked twice daily from 1958 until July, 1963. Thereafter, cows were machine milked twice daily with 13 hours between the night and the morning milking and 11 hours between the morning and the evening milking.

Fat Production

Eight cows were used for daily butterfat determinations for a 28 day period in September, 1963. Equal amounts of milk from a cow's morning and evening milk were combined for the Minnesota Babcock test (1950). Before analysis milk samples

were refrigerated to prevent spoiling.

Statistical Methods

1. Milk

The daily milk weights recorded for each cow during a particular year were added to obtain the actual milk production for that year. The estimated milk production for each cow was computed by multiplying the test day's milk yield times 7, 14 or 28 (the number of days in the particular test intervals) and adding these values to obtain the actual estimated yield for that year. The comparative accuracy of various testing intervals was measured by means of the average differences in yields, average percent error, standard deviation of the differences, coefficient of variation and frequency of errors of a certain magnitude.

2. Fat Percentage and Fat Production

The average fat percentage for the individual cows was calculated from the daily fat percent determined by Minnesota Babcock test; the daily fat percentages were added and then divided by 28 (number of days the fat test was performed) to obtain the average for each cow.

The actual total butterfat production in pounds for the period was determined by calculating the daily fat production and summing the daily production for the 28 day period. The estimated fat production for various testing intervals

was calculated by multiplying the fat production on the test day by the number of days in the testing intervals. For example, in order to estimate the fat production on the basis of weekly tests, the fat production on the test day was multiplied by seven.

Table 1 - Number of yearly records studied.

	Year						Total
	1958	1959	1960	1961	1962	1963	
Records studied	6	3	5	7	4	18	43

RESULTS AND DISCUSSION

Comparisons Between the Actual and the Estimated Milk Production

The actual yearly milk yields and deviations of yearly estimated milk yields recorded at different weighing intervals for 43 cows are presented in table 2. The results revealed that the average actual yearly milk production of the herd was 9097 with a range of 4988-12796 pounds. The average deviation of the estimated milk yields at weekly intervals was 38 pounds when the signs were ignored, with a range of 1-445 pounds. The average deviation for the milk yields estimated at a 14-day interval was 68 pounds when the signs were ignored, with a range of 4-228 pounds. The average deviations for the estimated milk yields at a 28-day interval was 239 pounds when the signs were ignored, with a range of -1152 to +867 pounds.

The average difference between recording one day every week and one day every four weeks was approximately 200 pounds for an average yearly milk yield of 9097 pounds, which amounts to less than one pound per day. These deviations when calculated as a percent of the actual milk yield of the individual cows ranged from 0.01-5.21, 0.05-5.27 and 0.11-10.66 for yearly milk yields estimated at 7, 14 and 28 days

Table 2 - Actual yearly milk yield and deviations of yearly estimated milk yields recorded at different weighing intervals from the actual yield for 43 cows.

Cow number	Actual yield in pounds	Deviations of estimated yields for different intervals					
		7 days		14 days		28 days	
		Pounds	Percent	Pounds	Percent	Pounds	Percent
7	10314	+108	+1.05	+195	+1.89	-33	-0.32
1	7961	-78	-0.98	-4	-0.05	-220	-2.76
3	6307	+141	+2.24	-168	-2.66	-7	-0.11
6	9875	+123	+1.25	+38	+0.38	-83	-0.84
9	10589	+356	+3.36	+70	+0.66	+77	+0.73
4	10805	-26	-0.24	-361	-3.34	-169	-1.56
4	10832	+1	+0.01	-35	-0.32	-1152	-10.66
6	6480	+338	+5.21	+235	+3.63	-104	-1.60
12	10183	+118	+1.16	+252	+2.21	+867	+8.51
2	9780	+227	+2.32	-142	-1.45	-561	-5.74
1	12181	-21	-0.17	-223	-1.83	-258	-2.11
5	10210	+104	+1.02	-152	-1.48	-310	-3.04
2	11405	+445	+3.90	-167	-1.46	-62	-0.54
7	7961	-5	-0.06	-99	-1.24	-442	-5.55
2	9388	+1	+0.01	-5	-0.05	-148	-1.58
5	8484	-79	-0.93	+44	+0.52	-276	-3.25
6	11584	-85	-0.73	-105	-0.91	-284	-2.45
8	5119	+16	+0.31	-270	-5.27	-209	-4.08
11	9023	+261	+2.89	-203	-2.25	-315	-3.49

Table 2 (Continued).

Cow number	Actual yield in pounds	Deviations of estimated yields for different intervals					
		7 days		14 days		28 days	
		Pounds	Percent	Pounds	Percent	Pounds	Percent
12	9494	+44	+0.46	-45	-0.47	-69	-0.73
13	6049	+2	+0.03	+21	+0.35	-75	-1.24
8	7613	-62	-0.81	+142	+1.86	+37	+0.48
11	12671	+136	+1.07	-97	-0.76	-628	-4.96
12	10542	-152	-1.44	-140	-1.37	-616	-5.84
14	8953	-246	-2.75	-250	-2.79	-528	-5.90
4	7096	-99	-1.40	+174	+2.45	-316	-4.45
6	12140	-162	-1.33	-185	-1.52	-288	-2.37
7	7340	+287	+3.91	-79	-1.08	-127	-1.73
12	12796	+181	+1.41	-106	-0.83	-480	-3.75
13	9592	-191	-1.99	-202	-2.11	-463	-4.83
14	8134	+34	+0.42	-170	-2.08	-125	-1.54
18	9278	-48	-0.52	+81	+0.87	-337	-3.63
15	7596	-81	-1.06	-228	-3.00	-65	-0.86
17	8025	+21	+0.26	+268	+3.34	-153	-1.91
20	12466	-34	-0.27	-264	-2.12	-182	-1.46
21	10273	-40	-0.39	+32	+0.31	-15	-0.15
22	6749	+61	+0.90	-172	-2.55	-283	-4.19
25	7260	+31	+0.43	+42	+0.58	-131	-1.80

Table 2 (Continued).

Cow number	Actual yield in pounds	Deviations of estimated yields for different intervals					
		7 days		14 days		28 days	
		Pounds	Percent	Pounds	Percent	Pounds	Percent
16	8209	+5	+0.06	-159	-1.94	-438	-5.34
8	10494	-78	-0.74	-204	-1.94	-549	-5.23
11	9658	-4	-0.04	-288	-2.98	-341	-3.53
29	4988	+5	+0.10	-18	-0.36	-46	-0.92
24	5271	+57	+1.08	+21	+0.40	-386	-7.32

intervals, respectively.

The frequency of cows with an estimated milk yield giving an error below 2, from 2-5, from 5-10 and from 10-15 percent is presented in table 3. The percent error was below 2, from 2-5, and from 5-10 at the 7-day recording interval for 35, 7 and 1 records, respectively. None of the records estimated an error greater than 10 percent.

The frequency of cows with an estimated milk yield giving an error below 2, from 2-5 and from 5-10 percent at the 14-day recording interval was 28, 14 and 1, respectively. None of the records exhibited an error greater than 10 percent.

The frequency of cows with an estimated milk yield giving an error below 2, from 2-5, from 5-10 and from 10-15 percent at the 28-day recording interval was 19, 15, 8 and 1, respectively.

Results of this study are in agreement with those reported by Davey and Alexander (1954) who found that the frequency of error larger than $\pm$10 percent was zero for weekly, 1 in 32 for fortnightly and 1 in 5 for monthly recording intervals. The results of the present study also agree with those reported by Nayaran *et al.* (1957) who found that the frequency of error larger than $\pm$5 percent was considerably less in 3 and 7 days testing intervals than in longer testing intervals. This study does not agree with those reported by Krempa and Krempa (1962) who compared daily milk

Table 3 - Frequency of cows with an estimated milk yield giving an error below 2, from 2 to 5, from 5 to 10 and from 10-15 percent of the actual milk yield for 43 cows.

Testing intervals	Percent frequency of error			
	Below 2 percent	2-5 percent	5-10 percent	10-15 percent
One week	35	7	1	-
Two weeks	28	14	1	-
Four weeks	19	15	8	1

recordings with those estimated at fortnightly and monthly intervals and found that the routine monthly recording gave, on an average, milk yields higher than the actual quantity. In the present study, the estimated milk yield at the 28-day interval was lower than the actual yearly milk production. These differences can be explained on the basis that if the monthly test dates fall in the early days of the month when the milk yields of individual cows are higher then there may be an overestimation of the total milk production. If the monthly test dates fall in the latter days of the month, there may be an underestimation of the total milk production, since the typical lactation curve shows a decline 4-6 weeks after calving. However this is not true for the first 4-6 weeks of the lactation when the milk yield is increasing; but the period of increasing is much shorter than that of decreasing milk production hence a test day in the early part of the month will tend to overestimate the milk production and a test day in the latter part of the month will underestimate the production. The test dates for the 28-day interval, in the present study, fell on the latter days of the month, usually between the 25th and 30th day of the month. This could possibly explain the differences in the results of this study as compared with those of Krempa and Krempa (1962).

The summary data for comparison between the average actual yearly milk production and the estimated yearly milk production recorded at different weighing intervals is shown

in table 4. The average actual milk production was 9097 pounds while those estimated were 9135, 9029 and 8857 pounds for recording intervals of 7, 14 and 28 days, respectively. It is evident from these results that the estimated yearly milk yield at the 7-day interval was a bit higher than the average actual yearly milk yield while the milk yields estimated at 14 and 28 days intervals were lower.

The average deviations for the estimated milk yields at 7, 14 and 28 days intervals from the actual yearly milk production were 38, -68 and -239 pounds, respectively. The deviations on the percent basis from the actual yields were 0.42, -0.75 and -2.63 at 7, 14 and 28 days intervals, respectively. It is interesting to note that the average differences are very small. The average differences of the estimated milk yield from the actual milk yield showed the expected tendency of maximum deviation for the once in 28 days and least for the once in 7 days recording intervals. The standard deviation of the differences was $\pm$145.75, $\pm$154.68 and $\pm$284.12 for recording intervals of 7, 14 and 28 days, respectively. The difference between the standard deviation of differences at 7 and 14-day interval is 8.93 which is negligible while the difference between recording the 7 and 28-day interval is 138.37. This difference for an average herd production of 9097 pounds can be tolerated in order to reduce expenses involved in recording milk production at shorter intervals.

Table 4 - Comparisons between the average actual yearly milk production and the average yearly milk production estimated from different weighing intervals 1958-1963.

	Actual yearly milk production	Estimation intervals		
		7 days	14 days	28 days
Average total milk (lbs.)	9097	9135	9029	8857
Average deviation from actual production (lbs.)		+38	-68	-239
Average percent deviation from actual production		+0.42	-0.75	-2.63
Standard deviation of the differences		±145.75	±154.68	±284.12
Coefficient of variation		1.60	1.72	3.21

The coefficient of variation was 1.60, 1.72 and 3.21 for 7, 14 and 28 days recording intervals, respectively. From the coefficient of variation it can be seen that the differences between the actual yearly milk production and those estimated at different intervals are very small. Even the variations of the estimated yearly milk yields at 28 days intervals can be tolerated without too great a sacrifice in accuracy. The differences in estimated milk yields of individual cows at the 28-day recording interval fell between -1152 and +867 pounds while the average deviation at the same recording interval was -239 pounds. This can be explained on the basis that the errors in the estimated milk yields above the actual milk yields and those errors in estimated milk yields below the actual milk yields tended to cancel each other. Therefore wherein the average differences (herd basis) may be small, the deviations of the estimated record of an individual cow from the actual could be quite large. From this study, it appears that the percent error in estimation of milk yield at 7, 14 and 28 days intervals from the actual milk yield is definitely low enough for estimating the average milk production for a herd of 50 cows. Since only 1 cow in 43 cows had an estimated milk yield that differed by greater than 10 percent at a testing interval of 28 days (table 3), it further seems possible that if a percent error of 10 percent can be tolerated, these recording intervals (7, 14 and 28 days) will give an accurate enough results for estimating the

milk yield of individual cows. The results of this study are in agreement with those reported by Jardim et al. (1956) who concluded that milk yields estimated at fortnightly intervals were a little lower than the actual milk yields. Smith and Quesenberry (1957) who found that the average monthly differences between the actual and the estimated milk yields were less than one pound per day also agrees with the present work. The percent error for estimated milk reported by Nayaran et al. (1957) and Youssef et al. (1962) also is in agreement with these results.

Comparisons Between the Actual and the Estimated Butterfat Percentages

The average actual butterfat percentages for individual cows are presented in table 5. The deviations of the average estimated fat percent units from the actual fat percent units ranged from 0.0-0.16, 0.01-0.3 and 0.03-0.54 for recording intervals of 7, 14 and 28 days, respectively. These deviations on a percent basis ranged from 0.24-3.75, 0.26-7.51 and 0.74-13.89 for the testing intervals of 7, 14 and 28 days, respectively. The frequency of cows with an estimated fat percentage giving an error below 2, from 2-5, from 5-10 and from 10-15 percent of the actual fat percentage is presented in table 6. The number of cows with an error below 2 and from 2-5 percent was four in both cases for the weekly estimated fat percentage. None of the cows had an estimated

Table 5 - Deviations of the estimated butterfat percentage (28 days) tested at different intervals from the actual butterfat percentage for eight cows.

Cow number	Average actual butterfat percentage	Deviations of percentage fat estimated at intervals of 7 days		14 days		28 days	
		Percentage unit	Percent	Percentage unit	Percent	Percentage unit	Percent
7	3.98	0	0	+0.22	+5.53	+0.22	+5.53
8	3.86	+0.10	+2.59	+0.29	+7.51	+0.54	+13.89
11	3.88	+0.08	+2.06	-0.13	-3.35	-0.28	-7.21
15	3.79	-0.01	-0.26	+0.01	+0.26	+0.11	+2.90
16	4.24	+0.16	+3.75	+0.06	+1.41	+0.06	+1.41
25	4.07	+0.03	+0.74	+0.02	+0.49	+0.03	+0.74
26	4.10	+0.01	+0.24	-0.25	-6.09	-0.20	-4.87
29	4.35	+0.15	+3.45	+0.30	+6.89	+0.05	+1.14

Table 6 - Frequency of cows with an estimated fat percentage (28 days) tested at different intervals, giving an error below 2, from 2 to 5, from 5 to 10 and from 10 to 15 percent of the actual fat percentage for eight cows.

Testing intervals	Percent frequency of error			
	Below 2 percent	2-5 percent	5-10 percent	10-15 percent
One week	4	4	-	-
Two weeks	3	1	4	-
Four weeks	3	2	2	1

fat percentage with an error greater than 5 percent at this recording interval.

The number of cows having an estimated butterfat percentage with an error below 2, from 2-5 and from 5-10 percent at the 14-day testing interval was 3, 1 and 4, respectively. None of the cows had an estimated fat percentage with an error greater than 10 percent.

The number of cows having an estimated butterfat percentage with an error below 2, from 2-5, from 5-10 and from 10-15 percent at the 28-day testing interval was 3, 2, 2 and 1, respectively.

The results of the comparisons between the average actual butterfat percentage and the average estimated butterfat percentage recorded at different intervals are presented in table 7. The average actual butterfat percentage was 4.03 percent while the average estimated butterfat percentages were 4.10, 4.11 and 4.10 for testing intervals of 7, 14 and 28 days, respectively. It is apparent from the results that there are very small differences between the actual percentage fat and those estimated at different testing intervals.

The average deviations from the actual butterfat percentage and the estimated butterfat percentage at different testing intervals were 0.07, 0.08 and 0.07 percent units for 7, 14 and 28 days, respectively. The standard deviation of the differences was $\pm$0.067, 0.197 and 0.251 for estimated

percentage			
Standard deviation of the differences	±0.067	0.197	0.251
Coefficient of variation	1.64	4.80	6.13

* The actual butterfat percentage was based on daily butterfat tests averaged for eight cows.

Table 7 - Comparisons between average actual butterfat percentage (28 days) and average estimated butterfat percentage tested on different testing intervals for eight cows.

	*Actual butterfat percentage	Testing intervals		
		7 days	14 days	28 days
Average butterfat percentage	4.03	4.10	4.11	4.10
Deviation from actual butterfat percentage		+0.07	+0.08	+0.07
Standard deviation of the differences		±0.067	0.197	0.251
Coefficient of variation		1.64	4.80	6.13

* The actual butterfat percentage was based on daily butterfat tests averaged for eight cows.

butterfat percentage tested at 7, 14 and 28 days intervals, respectively. The coefficient of variation was 1.64, 4.80 and 6.13 for 7, 14 and 28 days recording intervals, respectively. The differences between the percent fat estimated at 7 and 28 days testing intervals are relatively small. It can be safely concluded that percent fat estimated at 28 days testing intervals is reasonably accurate and can be used for herd management and breeding programs.

The results of this study agree with the work reported by Erb et al. (1952) who found that the average daily variation in percentage fat was 9.6 percent for the whole lactation period. Peterson (1950) reported that butterfat percentages can vary as much as 30 percent from day-to-day. Erb et al. (1953) observed a maximum difference from day-to-day of 0.50 percent in the pooled milk of 9-10 cows, but the maximum difference from day-to-day for 61 cows was 0.2 percent. The results of these workers indicate that as the number of cows in a trial increased the difference in percent fat between the actual and the estimated decreased.

The deviation in the estimated butterfat percentage from the actual butterfat percent estimated at a 7-day recording interval ranged from 0.0-0.16 percent for the eight cows studied. These results are in agreement with those reported by Krempa and Krempa (1962) who after comparing daily recorded fat percentage with fortnightly and monthly estimated fat percentage found that routine monthly recording

gave a lower fat percentage value than twice a month. Although variations exist for estimated fat percentages tested at various intervals, these variations are not large enough to significantly influence the accuracy of the estimated butterfat percentages from the actual butterfat percentage.

Comparisons Between the Actual and the Estimated Butterfat Production

The deviations of the estimated fat production from the actual fat production for individual cows ranged from 0.02-1.66, 0.09-2.67 and 0.07-3.71 pounds for 7, 14 and 28 days testing intervals, respectively. The deviations of the estimated fat production from the actual in percentages ranged from 0.09-7.55, 0.93-12.14 and 0.34-14.69 for intervals of 7, 14 and 28 days, respectively (table 8).

The frequency of cows with an estimated fat production giving an error below 2, from 2-5, from 5-10 and from 10-15 percent of the actual fat production is reported in table 9. The frequency of cows with an estimated fat production at a 7-day testing interval giving an error below 2, from 2-5 and from 5-10 percent was 2, 4 and 2, respectively. The frequency of cows with records giving an error above 10 percent was zero.

The frequency of cows with an estimated fat production, tested at a 14-day interval giving an error below 2, from 2-5, from 5-10 and from 10-15 percent was 1, 3, 3 and 1, respectively.

Table 8 - Deviations of the estimated butterfat production tested at different intervals from the actual butterfat production (28 days) for eight cows.

Cow number	Actual butterfat production (pounds)	Deviation of estimated butterfat at					
		7 days		14 days		28 days	
		Pounds	Percent	Pounds	Percent	Pounds	Percent
7	29.49	+0.26	+0.88	+2.55	+8.64	+3.43	+11.63
8	25.24	+0.67	+2.65	+1.79	+7.09	+3.71	+14.69
11	23.56	+0.80	+3.39	-1.05	-4.45	-0.38	-1.61
15	19.51	+0.88	+4.51	+1.25	+6.40	+2.33	+11.94
16	18.66	+1.20	+6.43	+0.90	+4.88	+0.60	+3.21
25	21.98	+1.66	+7.55	+2.67	+12.14	+2.12	+9.64
26	20.27	-0.02	-0.09	+0.19	+0.93	-0.07	-0.34
29	19.66	+0.93	+4.73	+0.52	+2.64	-0.57	-2.89

Table 9 - Frequency of cows with the estimated fat production (28 days) tested at different intervals, giving an error below 2, from 2 to 5, from 5 to 10 and from 10 to 15 percent of the actual fat production for eight cows.

Testing intervals	Percent frequency of error			
	Below 2 percent	2-5 percent	5-10 percent	10-15 percent
7 days	2	4	2	-
14 days	1	3	3	1
28 days	2	2	1	3

The frequency of cows with an estimated fat production, tested at a 28-day interval giving an error below 2, from 2-5, from 5-10 and from 10-15 percent was 2, 2, 1 and 3, respectively.

The results of the comparisons between the total actual butterfat production and the total estimated butterfat production recorded from different testing intervals are summarized in table 10. The average actual butterfat production was 22.3 pounds with a range of 18.7-29.5 pounds. The average estimated fat production was 23.1, 23.4 and 23.7 pounds for 7, 14 and 28 days intervals, respectively. The difference between the estimated butterfat production and the actual butterfat production was 3.58, 4.93 and 6.25 percent for 7, 14 and 28 days testing intervals, respectively. The deviations of the estimated butterfat production from total actual butterfat production were 0.8, 1.1 and 1.4 pounds for intervals of 7, 14 and 28 days, respectively. It is evident from these results that as the recording interval increased the error in estimation of fat production also increased. The standard deviation of the differences was least for the 7-day testing interval and greatest for the 28-day testing interval. The coefficient of variation for the estimated fat production was 2.26, 5.33 and 7.25 for 7, 14 and 28 days testing intervals, respectively. The differences between the estimated fat production at 7 and 28-day testing intervals was 0.60 pounds while this difference was only 0.30 pounds between the

Table 10 - Comparisons between the total actual butterfat production and total estimated butterfat production (28 days) recorded at different testing intervals, for eight cows.

	*Actual butterfat production (pounds)	Testing intervals **		
		7 days	14 days	28 days
Average total butterfat (lbs.)	22.30	23.10	23.40	23.70
Average deviation from actual butterfat production (lbs.)		+0.80	+1.10	+1.40
Percent deviation from actual butterfat production		3.58	4.93	6.25
Standard deviation of differences		±.522	±1.247	±1.719
Coefficient of variation		2.26	5.33	7.25

* The actual butterfat production was based on daily milk weighings and daily fat tests.

** The estimated butterfat was based on milk weights and fat test at 7, 14 and 28 days intervals, respectively.

estimated fat production at 7 and 14 days testing intervals. These results are in agreement with those of Bayley et al. (1952) who observed that frequency of error larger than 10 percent was 1 in 16 for bimonthly testing interval and 1 in 6 for quarterly testing intervals.

SUMMARY AND CONCLUSIONS

The yearly milk records of 43 cows completed during 1958-1963 have been used for studying the accuracy of estimating yearly milk production by different recording intervals. The average actual yearly milk production was calculated and compared with the average yearly milk production estimated by recording the production at different intervals. Average deviations, percent of the actual yield, standard deviation of the differences, coefficient of variation and frequency of error of certain magnitude have been calculated for recording intervals of 7, 14 and 28 days.

The average yearly milk production of the herd was 9097 pounds with a range of 4988-12796 pounds. The estimated yearly milk yields were 9135, 9029 and 8857 pounds at intervals of 7, 14 and 28 days, respectively. The magnitude of the differences increased as the interval of recording increased. The average deviations for estimated yields when signs were ignored were 38, 68 and 239 pounds at recording intervals of 7, 14 and 28 days, respectively. The percentage errors when signs were ignored were 0.42, 0.75 and 2.63 for recording one day in every 7, 14 and 28 days, respectively. The average difference between recording one day every 7 days and one day every 28 days was 201 pounds for an average yearly milk yield of 9097 pounds. The fre-

quency of error larger than ±5 percent of the actual yield was 1 in 43 for recording once every seven days and also 1 in 43 for once every 14 days. The frequency of error larger than ±5 percent was 1 in 5 for recording once every 28 days.

The butterfat determinations were made with the Minnesota Babcock reagent for a period of 28 days during September, 1963. The statistics used to study the comparative accuracy of the various testing intervals for estimation of milk production were also used to study butterfat percentage and butterfat production at different testing intervals.

The average fat percentage of the herd was 4.03 with a range of 3.79-4.35 percent. The estimated average fat percentage was 4.10, 4.11 and 4.10 for intervals of 7, 14 and 28 days, respectively. The difference between the estimated percent fat at various testing intervals is very small. The average deviation for estimated percent fat is 0.07, 0.08 and 0.07 at 7, 14 and 28 days testing intervals, respectively. When the average actual fat percentage was considered as 100, the percent differences ranged from 0.24-3.75, 0.26-7.51 and 0.75-13.89 for the estimated percent fat at recording intervals of 7, 14 and 28 days, respectively. The standard deviation of differences between the actual and the estimated percent fat was ±0.067, 0.197 and 0.251 for intervals of 7, 14 and 28 days, respectively.

The frequency of error larger than ±10 percent was zero for the estimated fat percentage at intervals of 7 and

14 days but was 1 in 8 at the 28-day testing interval.

The actual total butterfat production (28 days) for the individual cows was 22.3 pounds with a range of 18.66-29.49 pounds. The average estimated fat production (28 days) was 23.10, 23.40 and 23.70 pounds estimated at 7, 14 and 28 days recording intervals, respectively. The magnitude of the differences increased as the recording interval increased. The average deviations of the estimated butter production as a percentage of the actual butterfat production was 3.58, 4.93 and 6.25 for 7, 14 and 28 days testing intervals, respectively. The frequency of error larger than $\pm$10 percent was zero for estimated fat production at 7 days recording interval. The frequency of error larger than $\pm$10 percent was 1 in 8 and 1 in 3 for estimated fat production at 14 and 28 days testing intervals, respectively.

It can be concluded from the results of this study that milk recording and butterfat testing of cows at a 28-day interval throughout the year will give an accurate estimation of the yearly milk and butterfat production. Therefore a program based on milk recording and butterfat testing once every 28 days could be undertaken at a comparatively low cost and with a minimum amount of labor and yet accurate enough to be used for herd management and breeding purposes. However for some experimental purposes daily weighings of milk and testing it for butterfat is essential.

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