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VARIATION IN SOMATIC CELL COUNTS OF MILK SAMPLES FROM INDIVIDUAL COWS

By

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SYRSTAD, O. and I. RØN: *Variation in somatic cell counts of milk samples from individual cows.* Acta vet. scand. 1979, *20*, 555—561. — Somatic cell counts of 2570 milk samples from 765 cows collected bimonthly from November 1975 to May 1976 were transformed to logarithmic values and analysed statistically. Components of variance were estimated as follows: Herds 0.033 (13 %), age groups 0.021 (8 %), cows (within herds and age groups) 0.080 (31 %), months 0.014 (6 %), residual 0.107 (42 %). Correction of actual cell counts for the influence of milk yield on the day of sampling led to only small changes in the magnitude of the various components. The coefficient of correlation between samples from the same cow was computed as 0.60 when the samples were from the same lactation, and 0.37 for samples from consecutive lactations.

The proportionately small variation among herds as compared to the variation among cows of the same herd throws doubt on the efficiency of cell counting in samples of herd milk as a way of identifying cows with high cell counts.

somatic cell counts; milk; cows.

Somatic cell counting of milk has gained wide recognition as an aid to mastitis control in dairy herds. Cell counts in samples of herd milk have been used for several years for identifying herds with high infection levels. More recently, cell counting based on samples from individual cows has been proposed as an alternative, and presumably more efficient approach. It has even been suggested that individual cell counts might be useful for breeding purposes (*Dyrendahl* 1977). In some countries it has already been decided to incorporate cell counting in the ordinary milk recording programme.

The efficiency of the two strategies of sampling (individual vs. herd samples), as well as sampling frequency required, de-

pends on the importance of the different sources of variation (among herds, among cows in the same herd and among samples from the same cow). So far very little information on the distribution of the variation in cell counts has been available. The purpose of the present study is to make a contribution towards filling this gap.

DATA

The study was based on somatic cell counts in individual milk samples from 765 cows in 72 herds. Samples were collected bimonthly from November 1975 to May 1976. Each sample was a composite of morning and afternoon milk. Cell counts were obtained from a Fossomatic cell counter.

In addition to cell counts, age of cow, interval from preceding calving, and milk yield on day of sampling were also recorded. The data were used to estimate the effect on cell counts of age, stage of lactation and milk yield. The findings in that part of the study are reported elsewhere (*Syrstad et al.* 1979).

Several authors have drawn attention to the fact that cell counts have a very skewed distribution, with the result that the mean is much larger than the median. It has further been found that the distribution can be made approximately normal by transformation to logarithmic values. In the statistical analyses included in the present study the recorded cell counts were therefore replaced by their logarithms.

Previous studies have shown that the cell count is influenced by the amount of milk produced by the cow on the occasion of sampling. This is presumably an effect of dilution, and can be removed simply by multiplying the recorded cell count by the milk yield (cell count in thousands/ml times milk yield in kg $\simeq$ total cell count in millions). The logarithms of this product (log CM) were therefore included in the analyses along with the logarithms of the actual cell counts (log C).

METHODS AND RESULTS

The overall mean and standard deviation of logarithms of actual cell counts were computed as 2.096 and 0.498, respectively. The mean corresponds to a cell count of 125 thousand/ml. The range covered by the mean $\pm$ 1 s runs from 40 thousand to nearly 400 thousand/ml.

A two-way analysis of variance partitioned the variation into fractions among cows, among months of sampling, and residual. The results are presented in Table 1.

Table 1. Variation in somatic cell counts due to differences among cows, among months of sampling, and residual.

Source of variation	Degrees of freedom	Sums of squares		Mean squares	
		log C*	log CM*	log C	log CM
Cows	764	414.35	406.56	0.542	0.532
Months	3	26.44	33.14	8.815	11.046
Residual	1802	192.29	186.68	0.107	0.104

* For definitions, see under section: Data.

The analysis showed a highly significant variation among cows as well as among months of sampling. It is noticed that the correction for milk yield has led to a slight reduction in the variation among cows, while the variation among months has been increased. The residual variation is reduced by about 3 %.

Means and standard deviations of samples collected in various months are given in Table 2.

Table 2. Means and standard deviations of samples collected in various months.

Month	Number of samples	log C		log CM	
		mean	s	mean	s
November	649	2.01	0.59	3.21	0.57
January	646	2.03	0.53	3.25	0.51
March	616	2.27	0.32	3.51	0.32
May	659	2.08	0.46	3.32	0.47
Overall	2570	2.10	0.50	3.32	0.49

It is seen that samples taken in March had considerably higher mean values than samples of the other months, and at the same time were less variable. Examination of the data revealed that the March records contained no counts below 60 thousand cells/ml, while each of the other months had several samples below this level. It was suspected that this difference

might have been caused by an erroneous calibration of the cell counter during the period when the March samples were analysed. If the March counts were biased upwards by, say 50 thousand cells/ml, this would explain most of the difference between March and the other months, not only in mean values, but also in variability (after transformation to logarithms). The variation among months obtained in these analyses should therefore be interpreted with caution.

The residual mean squares in Table 1 estimate the variance among samples from the same cow when the difference between months has been removed. The standard deviation within cows was computed as about 0.32, which corresponds to a change in actual cell count by a factor of 2.1.

Included in the within-cow variation (residual in Table 1) is also the variation due to stage of lactation. It was, however, found that this source of variation is of minor importance, particularly when the cell counts have been adjusted for the influence of milk yield (*Syrstad et al.* 1979). It was therefore ignored in the present study.

From the variation ascribed to cows in this analysis, fractions due to age of cow and to differences among herds can be separated. This was done in two nested analyses of variance. The results are presented in Table 3.

Table 3. Subdivision of the variation among cows (Table 1) into fractions due to herds, age and residual.

Source of variation	Degrees of freedom	Sums of squares		Mean squares	
		log C	log CM	log C	log CM
Herds	71	109.48	85.34	1.542	1.202
Age	9	47.61	62.14	5.290	6.904
Residual	684	257.26	259.08	0.376	0.379

The analyses showed highly significant differences both among herds and among age groups. It is seen that the correction of cell count for milk yield (by multiplication) has led to a decrease in the variation among herds, while the variation due to age has been increased. The latter is a consequence of the fact that both milk yield and cell count increase with advancing age.

Components of variance and proportionate distribution of variance are presented in Table 4.

Table 4. Components of variance in somatic cell counts.

Source of variation	Components of variance		Proportions of variance	
	log C	log CM	log C	log CM
Herds	0.033	0.023	0.13	0.09
Age groups	0.021	0.028	0.08	0.11
Cows/herd/age	0.080	0.082	0.31	0.32
Months	0.014	0.017	0.06	0.07
Residual	0.107	0.104	0.42	0.41

About 10 % of the total variation in cell counts can be ascribed to differences among herds, and a similar proportion to the influence of age. Slightly more than 30 % of the variation is due to differences among cows of the same age and within the same herd, while the variation among samples from the same cow accounts for about 40 %.

The components of variance reported in Table 4 provide estimates of intraclass correlation (among samples from the same cow) of about 0.50 for both log C and log CM. When the difference among months has been removed, these estimates increase to about 0.55. It might, however, be expected that the magnitude of the correlation declines as the sampling interval is increased. Moreover, the correlation might be lower for counts from different lactations than for counts obtained at various stages of the same lactation. Coefficients of correlation were therefore computed for pairs of samples grouped by months of sampling and according to whether the samples were from the same lactation or from consecutive lactations. The coefficients in Table 5 refer to log CM.

The coefficients of correlation between samples from the same lactation are consistently high, and almost independent of the sampling interval. The correlation between samples from consecutive lactations is considerably lower, although highly significant in all groups with reasonably large numbers. The weighted averages of the correlation coefficients were 0.60 for samples from the same lactation and 0.37 when the samples were from consecutive lactations.

Table 5. Correlation between paired samples from the same cow.

Months of test	Samples from same lactation		Samples from consecutive lactations	
	number of cows	coefficient of correlation	number of cows	coefficient of correlation
Nov.–Jan.	530	0.59	12	0.10
Nov.–March	434	0.53	71	0.33
Nov.–May	401	0.53	144	0.40
Jan.–March	522	0.65	36	0.36
Jan.–May	483	0.66	91	0.44
March–May	554	0.63	31	0.24

DISCUSSION

The most interesting finding in this study is probably that only about 10 % of the total variation in somatic cell counts could be ascribed to variation among herds. By comparison, about 30 % of the variation in milk yield is due to herd differences. The individual (within herd) variance in cell count was found to be three or four times larger than the variance among herds. This indicates that high cell counts are not limited to particular herds, and might suggest that managerial practices (milking technique etc.) are of less importance than has sometimes been maintained.

The small proportion of variance which is among herds seems to indicate that somatic cell counting in samples of herd milk is rather inefficient in identifying cows with high cell counts. If the purpose of cell counting is to screen cows for further investigations (e.g. CMT or microbial examination of quarter samples), individual samples should be expected to be much more efficient than herd samples.

In spite of the fairly high correlation between samples from the same cow, the variation from sample to sample is large. A previous study (*Syrstad & Røn* 1978) showed that the variation in cell counts between samples taken at successive milkings over a period of two weeks was fairly low. The large sample-to-sample variation in the present data can therefore not be ascribed to inaccurate sampling or counting. Most of the variation must be caused by changes in actual cell counts over time. This suggests that rather frequent tests would be required.

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SAMMENDRAG

Variation i celletall i melkeprøver fra enkeltkyr.

Artikkelen gjengir resultater fra en statistisk analyse av data for antall somatiske celler i en prøveserie på 2570 melkeprøver fra enkeltkyr. Serien omfattet 72 buskaper med tilsammen 765 kyr, og prøvene ble tatt ut hver annen måned fra november 1975 til mai 1976. De registrerte celletallene ble transformert til logaritmiske verdier og analysert i en serie varians- og kovariansanalyser.

Analysene ga disse varianskomponentene for de variasjonsårsakene som ble undersøkt (tall i parentes angir den prosentiske fordeling av variasjonen):

Buskaper	0,033 (13 %)
Aldersgrupper	0,021 (8 %)
Kyr (innen buskaper og aldersgrupper)	0,080 (31 %)
Prøvemåneder	0,014 (6 %)
Rest („feil")	0,107 (42 %)

Korrigering av det registrete celletallet for virkningen av melkemengden på prøvedagen førte bare til mindre endringer i de ulike varianskomponentene. Korrelasjonskoeffisienten for korrelasjon mellom celletall i to prøver fra samme ku ble utregnet til 0,60 når prøvene var fra samme laktasjon, og til 0,37 for prøver fra to laktasjoner etter hverandre.

Det mest interessante resultatet av denne undersøkelsen er sannsynligvis at bare en mindre del av variasjonen i celletall kan tilskrives forskjell mellom ulike buskaper. Dette viser at høye celletall ikke er avgrenset til særskilte buskaper, og tyder på at celletelling i prøver av leverandørmelk er lite effektivt når formålet er å finne fram til kyr med høyt celletall i melken. Det er også grunn til å merke seg den relativt høye korrelasjonen mellom ulike prøver fra samme ku.

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