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Statistical Relationship between Milk Constituents used in Breeding Programs during Lactation: French Case Study

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Abstract

Milk mainly composed of water, proteins (casein), sugar (lactose), fat and minerals (calcium and phosphorus). Also milk contains a few pigment, enzymes, vitamins, phospholipids and gas. A team showed a close relation between graziery feed composition, milk products quality and community health level. Although, statistical analysis in some references showed different correlations between milk parameters and consumed feed composition in grazieries. Currently, scientists are working hard on cow breeding programs to produce milk products having high values. The present work is concerned into adjusting the breeding program by defining the possible correlations between the repeatability of basic milk constituents. Different composite samples of herd milk have been collected in three periods [April-October, 2009] each month over an extended period of time. Twelve cows completed 27 scheduled sample days and five completed the first 18 days. Atmospheric records were gathered over 24-hr. during milk production. Some statistical components were estimated as the repeatability, variance due to days, and variance due to periods and the Chi-square was implemented to evaluate the differences between correlation coefficients. Low coefficients of variation have referred to the independent correlations among the variables in the breeding program.

Keywords: Breeding program; milk products; correlations; lactation; yield

Introduction

During the past three decades, there has been much discussion of the milk-pricing system and means of altering it for the mutual benefit, of the producer, processor, and consumer [1]. Likewise, interest has increased in the possibility of changing the relative amounts of solids in milk [2].

If such marketing changes were made, it would be desirable to adjust the breeding program to produce a product having maximum value. Specifically, if constituent other than milk fat was to become a criterion of value, then the breeder would need to be able to apply successfully selection pressure for that constituent. Since this must be possible if progress is to be made by the breeder, it is essential that these constituents be evaluated with respect to their repeatability.

The data that have been reported in the literature [3-8] show relatively high coefficients of correlation between the major milk constituents. These values have been obtained by evaluating milk samples obtained by one or more of the following sampling patterns: (a) one or more days composite sample of herd milk taken once each month over an extended period of time; (b) a one or more days' composite sample of the milk of individual cows taken once a month over an extended period of time; (c) two or more days' composite sample of the milk of individual cows taken every 5 wk. over an extended period of time; or (d) a one-day composite sample of the milk of cows once a week or some other stated time interval over an extended period of time. In such sampling procedures, the daily variation of the individual cow would be minimized. Consequently, it was deemed desirable to examine the daily variation in the major constituents of milk periodically throughout the lactation of individual cows, in order that the relative importance of this source of variance might be assessed.

Experimental procedure

Seventeen winter-calving Armorican cows that had calved prior to April 1, 2009, and were in the same general stage of lactation, were selected for this testing program. A milk-sampling schedule was arranged so that each cow would be intensively sampled during April, July, and October. In each sample month, each cow was to have a one-day composite of night and morning milk taken for three consecutive days in each of three periods. Period 1 consisted of the 3rd, 4th, and 5th; Period 2 consisted of the 15th, 16th, and 17th, and Period 3 consisted of the 24th, 25th, and 26th days of the month. The three-day periods within each month were selected by chance and the months were chosen so that coverage of the entire lactation would be as broad as possible under such a sampling program. Therefore, each sample month could be used both as a general stage of lactation and as a season of the year.

Twelve of the cows completed the 27 scheduled sample days, while the other five completed only the first 18 days. Daily composite samples were taken. The cows were maintained in a dry lot operation with limited access to pasture. The percentages of the following components were determined: (a) total protein (TP) [9]; (b) milk fat (F) [10]; (c) total solids by the Mojonnier method (TS_m) [11] and by the Cenco method (TS_c) [12], and (d) solids-not-fat, (SNF) by difference from the Mojonnier procedures [13]. Daily milk yield (DMY) in pounds (453.6 gr) per sample day; averaged barometric pressure; maximum and minimum air temperature, and solar radiation in Langley units were concomitantly recorded. The atmospheric data were taken over the 24-hr. period during which the milk was produced.

Standard statistical procedures were followed throughout [14]. An analysis of variance procedure was used to obtain the components of the total variance due to: (a) consecutive days within a 3-day period; (b) periods within the month, and (c) months for each cow and factor related to the milk that was produced. The data were analyzed as obtained and were not corrected for age or computed to cover the total milk produced during the entire lactation.

The equation, $R_1 = \frac{\sigma_e{}^2}{\sigma_e{}^2+\sigma_p{}^2}$ was based on variances within cows and within months. R_1, $\sigma_e{}^2, \sigma_p{}^2$ represent repeatability estimate, variance due to days, and variance due to periods, respectively. The equation, $R_2 = \frac{\sigma_e{}^2+\sigma_p{}^2}{\sigma_e{}^2+\sigma_p{}^2+\sigma_m{}^2}$ was based on variances within cows and over months. R_2 and $\sigma_m{}^2$ represent repeatability estimate and variance due to months, respectively. All repeatability values were obtained for individual cows, and then pooled over cows to obtain a single within-cow estimate for each factor by each method cited above.

Estimates of correlation coefficients were established between the milk constituents examined and between those constituents and total milk yield and the weather data previously mentioned. Coefficients were calculated for individual cows then pooled over periods within months and over months, to obtain an estimate of the coefficient of correlation that would be most applicable as a lactation estimate under the conditions of this sampling schedule. The Chi-square test was used to evaluate the differences between correlation coefficients of a given set of data [15].

Results and Discussion

Pooled estimates of repeatability for individual cows for each of the methods of calculation are shown (Table 1).

Table 1. Pooled within-cow repeatability estimates and relative importance and distribution of daily, periodic, and monthly components of variance.

Factor (%)	Repeatability		Number of times each source of variance was of greatest importance for R_2								
		Day			Period			Month			
	R_1	R_2	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
F	0.99	0.84	**15**	**2**	0	0	**9**	**8**	2	8	7
SNF	0.96	0.92	**16**	**1**	0	0	**5**	**12**	1	11	5
TS_m	0.99	0.88	**13**	**4**	0	0	**3**	**14**	4	10	3
TS_c	0.89	0.80	**10**	**6**	1	0	**5**	**12**	7	6	4
TP	0.75	0.60	4	5	8	0	11	6	**13**	**1**	3
DMY	0.33	0.17	0	6	11	0	11	6	**17**	**0**	0

It was evident from the estimated mean square of the analyses of variance, for both per cent of fat and SNF, that day and period were more important as sources of variation than were months. Total solids showed the same trend as fat and SNF, by both the Mojonnier (TS_m) and Cenco procedures (TS_c). It was of interest to note, however, that daily variation appeared to be greater by the Mojonnier procedure than by the Ceneo procedure.

Differences between months were the greatest sources of variation for most of the cows with respect to the per cent of total protein and daily milk yield. Periodic and daily variations were of lesser importance. This might have been anticipated with respect to daily milk yield. The distribution of the importance of the sources of variance for each factor measured is shown in Table 1. The size of R_1 parallels this distribution. Therefore, it would appear to be necessary to sample all of the constituents of milk that were examined here more frequently than daily milk yield, to obtain production estimates for a given period of time that were equally accurate for all factors. The relative frequency of sampling required for each factor will vary as the importance of the daily, periodic, and monthly component of variance changes.

The pooled estimates of the linear correlation coefficients between the milk constituents studied and between each of these constituents and total milk yield and atmospheric data are shown (Table 2). Those coefficients which exceeded the Chi-square value of 0.05 were included to give an indication of the extent to which those traits were related.

Table 2. Pooled linear coefficients of correlation.

Factors	r	Factors	r	Factors	r	Factors	r
1, 2	-0.135	2, 4	**0.326**[a]	3, 7	0.001	5, 6	**0.089**[a]
1, 3	**0.453**[a]	2, 5	0.129	3, 8	-0.063	5, 7	**-0.183**[a]
1, 4	0.304	2, 6	0.111	3, 9	-0.036	5, 8	**-0.184**[a]
1, 5	0.019	2, 7	-0.134	3, 0	0.135	5, 9	**-0.211**[a]
1, 6	**-0.022**[a]	2, 8	0.025	4, 5	0.206	5, 0	**-0.026**[a]
1, 7	0.197	2, 9	0.078	4, 6	**-0.060**[a]	6, 7	**-0.130**[a]
1, 8	-0.161	2, 0	0.141	4, 7	-0.002	6, 8	**-0.122**[a]
1, 9	-0.125	3, 4	**0.607**[a]	4, 8	-0.114	6, 9	**-0.119**[a]
1, 0	0.118	3, 5	0.127	4, 9	-0.075	6, 0	**-0.031**[a]
2, 3	**0.814**[a]	3, 6	**0.062**[a]	4, 0	-0.094		

1: % F, 2: % SNF, 3: % TS_m, 4: % TS_c, 5: % TP, 6: pound DMY, 7: Average barometric pressure, 8: Maximum temperature (° F.), 9: Minimum temperature (° F.), 0: Solar radiation (gm. cal/min/cm^2)

[a] Exceeded Chi-square value at 0.05.

The correlation between F and SNF attained its highest absolute value during the month of July, or just past mid-lactation for most of these cows. The negative relationship between these factors is contrary to the findings of [16], but agrees with the data of [17] that these two factors do not vary together. The correlation between fat and total protein fluctuated very closely about zero. This value is much lower than those reported by others [2], [13], [10]. Reasons for this difference may be in the frequency with which the animals were sampled, the fact that one-day samples were used rather than composites of two or more days at less frequent intervals, and a possible real difference in the populations sampled due to breed, selection program, and environmental conditions which may have exerted natural selection pressure on the cattle involved. These pooled coefficients represent individual cow relationships rather than some other and perhaps broader basis. These correlations indicate the possibility of altering the composition of the SNF fraction of milk without affecting the SNF-TS relationship.

The relationships between weather data and factors concerning milk production were found to be small and somewhat variable as judged by the number of estimates of correlation that exceeded the Chi-square value of 0.05.

The correlations between F and barometric pressure were all positive in character, whereas those between SNF and barometric pressure were all negative. Total solids, by both procedures, were essentially independent of barometric pressure as judged by the pooled estimates of correlation. Total protein and DMY were both negatively correlated with barometric pressure, but the number of coefficients exceeding Chi-square at 0.05 reduces their usefulness.

The general relationships between maximum and minimum temperatures and factors related to milk production were negative. The only pooled estimate that was positive in both instances was SNF and this did not differ markedly from zero in either instance. With the exception of SNF, the results obtained by correlating solar radiation to the factors concerned with milk production were similar to those obtained by relating barometric pressure to the same set of factors. In the correlation of SNF and solar radiation the coefficient was of the same general magnitude as for SNF and barometric pressure, but different in sign. The reason for such a change in sign was not to be found in the available data.

Conclusion

We found in months greatest sources of variation for the cows in respect to the per cent of total protein and daily milk yield. However, periodic and daily variations were of less significant. Therefore, we suggest sampling frequently than daily the entire constituents of milk to obtain a good production estimates for a given period of time that is equally accurate for all factors.

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