UPPER MIDWEST MARKETING AREA

ANALYSIS OF COMPONENT LEVELS AND SOMATIC CELL COUNT IN INDIVIDUAL HERD MILK AT THE FARM LEVEL 1999

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ABSTRACT

Data on the butterfat, protein, other solids and solids-not-fat (SNF) levels and somatic cell count (SCC) were examined for producer milk associated with the Upper Midwest Order during 1999. Results from the analysis include: average levels, regional and seasonal variation in component levels and SCC, and statistical relationships among the four components in individual herd milk at the farm level.

The value of milk pooled on the Upper Midwest Order has been determined on the basis of multiple component pricing (MCP) since 1996. In this study, component prices from 1999 were applied to producer milk associated with the Upper Midwest Order, thus providing an opportunity to examine how component levels influence the value of producer milk.

Major findings of the analysis include:

1) Weighted average component levels and SCC for 1999 were 3.73% butterfat, 3.19% protein, 5.51% other solids, 8.70% SNF and 366,000 SCC.

2) For 1999, weighted average butterfat, protein and SNF levels were lowest in July and highest during the late fall and winter. In contrast, other solids levels varied little during the year. Weighted average SCC were lowest in December and highest in August.

3) In 1999, the range of monthly average component levels within one standard deviation of the mean was: 3.50% to 4.02% for butterfat; 3.04% to 3.38% for protein; 5.36% to 5.60% for other solids; 8.47% to 8.90% for SNF; and 207,000 to 579,000 for SCC.

4) Based on the data for 1999, the following regression equations were derived:

$$SNF = 7.00\% + 0.4484\ (BF)$$
$$SNF = 5.32\% + 1.0486\ (PRO)$$
$$PRO = 1.57\% + 0.4342\ (BF)$$

5) The annual weighted average value of butterfat, protein, and other solids adjusted for SCC, was $12.69 per cwt. for the market in 1999. Protein was the most valuable component, contributing nearly half of the total value.

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I. INTRODUCTION

The data for this study were collected for milk marketed in 1999 from producers on the Upper Midwest Milk Marketing Order. 1999 was the fourth year that multiple component pricing (MCP) was in effect for payments to producers under the order. MCP was adopted in five midwestern Federal milk orders, including the Upper Midwest, effective January 1, 1996. Under the MCP plan implemented, producer milk is priced primarily on the basis of butterfat, protein and other solids[2] with adjustments for somatic cell count (SCC). Prior to the introduction of MCP, earlier studies on component levels in individual herd milk were conducted for a sample of producers on the Upper Midwest Order. In those studies, butterfat, protein, lactose and solids-not-fat (SNF) levels and SCC in milk were analyzed to determine: average levels, regional and seasonal variation in component levels and SCC, and statistical relationships among the four components in individual herd milk at the farm level. In the study completed for 1995, for example, about 68% of the producers and 65% of the producer milk in the market were included. In this study, monthly payroll records for all producers associated with the Upper Midwest Order were used to determine monthly and annual average: butterfat, protein, other solids and solids-not-fat levels and SCC. Seasonal and regional variations of component levels and SCC were noted and analyses were conducted to evaluate the strength of relationships among components.

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[2] Other solids are defined as solids-not-fat less protein.

II. DATA AND METHODOLOGY

The data used in this analysis are from monthly payroll records for producers associated with the Upper Midwest Order. The data include all pooled producer milk and milk associated with the order but not pooled in some months because of unusual price relationships and/or qualification circumstances. Also, there are a number of instances in which there are multiple cases representing producer milk from one farm. These are situations where more than one producer received a share of the milk check, or there is more than one bulk tank on the farm. For each producer, total monthly milk marketings and simple monthly average component levels and SCC from payrolls submitted to the Market Administrator's office were used to calculate "weighted" average component levels and SCC for this analysis. All producer milk was included in the analysis which follows unless otherwise noted in the text, figures or tables.

Many factors such as weather, feed quality and feeding practices, breed of cattle, etc., may impact component levels and relationships among components in milk. No attempt was made to estimate the specific effects of such factors on milk composition. However, average component levels were examined for seasonal or within-year variation.[3] In addition, component levels were analyzed on a regional basis by examining six geographic regions within the milk procurement area generally defined as: northeastern Minnesota-northwestern Wisconsin (Region 1); central to southeastern Minnesota-west central Wisconsin (Region 2); southwestern Minnesota-northern Iowa (Region 3); northwestern Minnesota, eastern North Dakota and a small portion of northeastern South Dakota (Region 4); western North Dakota (Region 5); and the western portion of the procurement area in South Dakota (Region 6). These regions were chosen so as to generally reflect geographically homogeneous production regions.

Ordinary Least Square (OLS) regression analysis was used to determine the relationship between individual components, for example, butterfat vs. SNF, butterfat vs. protein and protein vs. SNF.

The cumulative value of butterfat, protein and other solids, adjusted for SCC, on an annual per cwt. basis was examined to observe how milk values varied under differing constraints. Monthly Federal order component prices that apply to the Upper Midwest Order were used to calculate milk values for this study.

[3] According to historical data gathered through the Market Administrator's Marketing Service program, the "normal" seasonal variation in a given component level, from one year to another, follows a similar pattern.

III. SEASONAL AND REGIONAL VARIATION IN MILK COMPONENT LEVELS AND SOMATIC CELL COUNT

Seasonal Variation in Milk Component Levels and Somatic Cell Count

Seasonal changes in component levels for 1999 appeared to be relatively "normal". Beginning in January, component levels, with the exception of other solids, tapered off during the spring to low points in July, then rose to peak levels at some time in the late fall or winter. The seasonality of changes and magnitude of variation in component levels during the year were generally similar to the observed results from previous studies. Seasonal variation in the monthly average SCC appeared to be typical, with higher levels in the summer and lower levels in the fall and winter. Monthly weighted average component levels and SCC for 1999 are summarized in Table 1 and miscellaneous annual statistics, in addition to weighted averages, are summarized in Table 2.

During the year, butterfat levels dropped from 3.81% in January to 3.58% in July, then rose to 3.82% during October through December. Protein and SNF showed similar seasonal patterns during the year by bottoming out in July and peaking in October. The range of variation for butterfat, protein and SNF was 0.24, 0.22 and 0.21 percentage points, respectively. Other solids demonstrated the narrowest range of variation with no apparent seasonal pattern. Other solids levels ranged from a high of 5.55% in April to a low of 5.47% in September. The seasonal high SCC of 445,000 was reached in August before dropping to 328,000 in December, a change of 117,000 during the year.

For the year, the mean butterfat and protein levels were higher than the weighted average for each respective component. The means relative to the weighted averages for these components indicates that smaller producers (in terms of monthly milk deliveries) tended to have higher levels of these components than their larger counterparts. Conversely, the means for other solids and SNF were lower than the weighted averages for the respective components indicating that larger producers tended to have higher levels of these components than smaller producers. For the year, the mean SCC (393,000) for 1999 was higher than the weighted average (366,000) indicating that larger producers tended to have, on average, lower SCC than their smaller counterparts. Moreover, the median SCC level (363,000) was lower than the weighted average (366,000), indicating that the producer tests in the distribution were skewed toward higher SCC levels (see Appendix Figure A-5).[4]

[4] The median represents the middle value of all SCC tests, ranked numerically from the lowest to the highest SCC level. The median, unlike the mean, is not influenced by outliers. The skewness statistic for SCC was 0.974. Skewness is a measure of the asymmetry of a distribution. A normal distribution is symmetric with a skewness value of zero. A skewness value greater than one indicates a distribution that differs significantly from a normal distribution.

Table 1

Weighted Average Levels of Selected Components and Somatic Cell Count in Milk by Month

1999

Month	Butterfat - % -	Protein - % -	Other Solids - % -	Solids-Not-Fat - % -	Somatic Cell Count - 1,000 -
January	3.81	3.25	5.51	8.76	344
February	3.77	3.21	5.53	8.74	357
March	3.77	3.20	5.54	8.74	349
April	3.75	3.15	5.55	8.71	354
May	3.69	3.14	5.54	8.68	359
June	3.63	3.12	5.52	8.63	382
July	3.58	3.07	5.50	8.57	412
August	3.59	3.13	5.48	8.61	445
September	3.70	3.23	5.47	8.70	398
October	3.82	3.29	5.49	8.78	341
November	3.82	3.28	5.48	8.76	329
December	3.82	3.26	5.49	8.75	328
Minimum	3.58	3.07	5.47	8.57	328
Maximum	3.82	3.29	5.55	8.78	445
For: 1999	3.73	3.19	5.51	8.70	366
1998	3.70	3.17	5.53	8.70	355

The range of component levels observed in the data was fairly wide. Individual monthly average butterfat levels in the data were as low as 2.19% and as high as 6.04%; protein levels ranged from 2.05% to 4.55%; other solids levels ranged from 3.54% to 6.05%; SNF levels ranged from 5.59% to 9.97%; and SCC ranged from 19,000 to 1,500,000.

However, during the year, the component test levels and SCC levels in most producer milk were within one standard deviation of the mean.[5] The range of component levels within one standard deviation of the mean were: 3.50% to 4.02% for butterfat; 3.04% to 3.38% for protein; 5.36% to 5.60% for other solids; 8.47% to 8.90% for SNF; and 207,000 to 579,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the

[5] By definition, for a *normal distribution*, approximately 68 percent of observations are within one standard deviation of the mean.

1999 data, as in previous years, were within these ranges[6] (see also Appendix Table A-2 and Appendix Figures A-1 through A-5).

Table 2

Component Levels and Somatic Cell Count of Milk:
Weighted Average, Mean, Standard Deviation, Median and Total Range

1999

Month	Weighted Average	Mean	Standard Deviation	Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.73	3.76	0.26	3.75	2.19	6.04
Protein	3.19	3.21	0.17	3.19	2.05	4.55
Other Solids	5.51	5.48	0.12	5.50	3.54	6.05
SNF	8.70	8.69	0.22	8.70	5.59	9.97
SCC (1,000's)	366	393	186	363	19	1,500

Regional Variation in Milk Component Levels and Somatic Cell Count

Milk component levels and SCC were examined by region. The procurement area for milk associated with the Upper Midwest Order during 1999 was divided into six relatively homogeneous geographic regions, which were examined for differences in component levels and SCC. The county boundaries of these regions and weighted average component levels and SCC for the respective regions are shown in Figure 1. Yearly average component levels for 1999 are noted for each region on the map and are also summarized in Table 3.

Differences in average component levels and SCC between the six regions were observed, however, those differences were not found to be statistically significant (see Table 3). Region 1 showed the highest average butterfat and protein levels for the fourth consecutive year, while Region 5 had the lowest butterfat level and Region 2 had the lowest protein level. Other solids levels did not exhibit a consistent pattern and generally varied little from the average for the procurement area. Average SCC were lowest in Region 5 and highest in Regions 2 and 4. Detailed regional information by month for 1999 is presented in Table A-2 (see Appendix).

[6] The percentage of observations within one standard deviation of the mean in the 1999 data was higher than the approximate percentage attributed to a normal distribution. The kurtosis statistic measures the extent to which observations cluster around a central point. The kurtosis statistic is zero for a normal distribution. Each component and the SCC had kurtosis statistics that were greater than zero, which indicates more observations are clustered around the means than would be attributed to a normal distribution of observations.

FIGURE 1

UPPER MIDWEST ORDER MILK PROCUREMENT AREA

WEIGHTED AVERAGE COMPONENT LEVELS

AND SOMATIC CELL COUNTS

1999

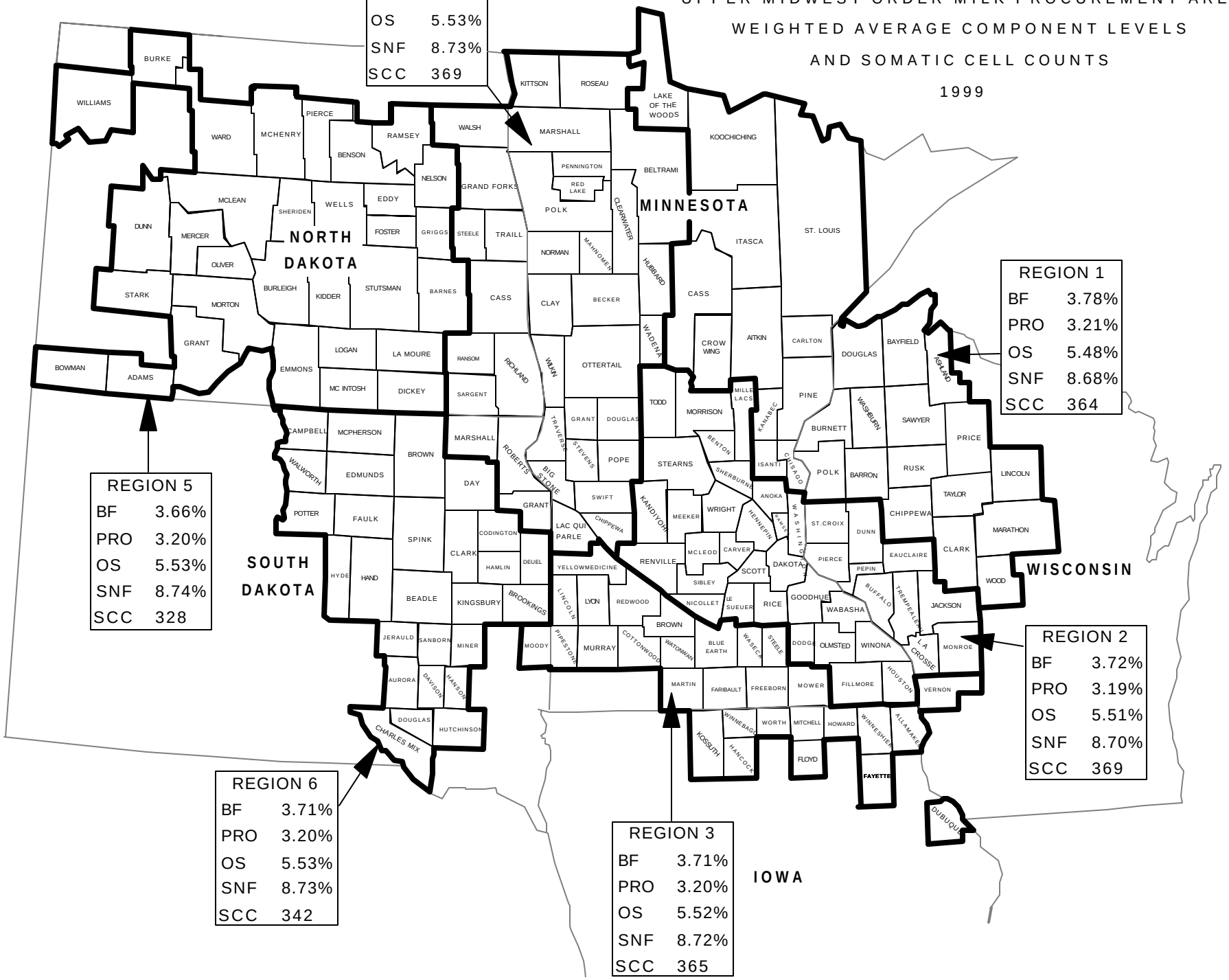


Table 3

Weighted Average Components Levels and Somatic Cell Count in Milk by Region

1999

Region	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
Region 1	3.78	3.21	5.48	8.68	364
Region 2	3.72	3.19	5.51	8.70	369
Region 3	3.71	3.20	5.52	8.72	365
Region 4	3.70	3.20	5.53	8.73	369
Region 5	3.66	3.20	5.53	8.74	328
Region 6	3.71	3.20	5.53	8.73	342
Market	3.73	3.19	5.51	8.70	366
Minimum	3.66	3.19	5.48	8.68	328
Maximum	3.78	3.21	5.53	8.74	369

IV. STATISTICAL RELATIONSHIPS AMONG MILK COMPONENTS

Regression analysis was used to estimate the linear relationship between components. Results from the 1999 data were compared with results from previous Upper Midwest Order studies (1993-1999), the findings of Halverson/Kyburz (1986), Jack et al. (1951) and Jacobson (1936) when comparable regression equations were derived. The regression equations in this section are of the following general form:

$$Component\ A = c + b\ (Component\ B) + e$$

where, *Component A* is the dependent variable, *c* is a constant, *b* is a coefficient, *Component B* is an independent variable, and *e* is an error term.

Monthly variation between component levels was also examined by introducing "month" variables into the equations to reflect seasonality. The general form of these equations are:

$$Component\ A = c + b(Component\ B) + m(February) + \ldots + m(December) + e$$

where, in addition to the previously defined general form, *m* is a coefficient, and February through December are dummy variables (January is left out to establish a base line for the other months). Month coefficients for the equations are summarized in Table A-3 (see Appendix).

Generally, the inclusion of month variables in the equation did not significantly improve an equation's ability to explain the relationship between components. However, nearly all of the month variables were statistically significant in each of the three final equations obtained through stepwise regression. These equations showed that the seasonal variation observed in component levels and the variation in the relationship between components are valid and measurable

Butterfat Levels as a Predictor of SNF Levels

The regression equation, which uses butterfat levels to predict SNF levels, is written as:

$$SNF = c + b(BF).$$

In Table 4, comparisons are made between the results derived in each of the Upper Midwest Order studies and those derived by Halverson/Kyburz, Jack et al. and Jacobson. While a full comparison of the estimates was not possible, the equations did not appear to be appreciably different. The constants of all eleven equations differed little from one another. The coefficients for butterfat, on the other hand, appear to cycle from year-to-year within a range of 0.3817 from Mykrantz 1993 to 0.4640 for Halverson/Kyburz. The butterfat coefficient derived from the 1999 data was within that range at 0.4484. No attempt was made to identify possible causes for the change in the butterfat coefficient.

The monthly regression equations generally performed as expected: all parameters were statistically significant and of the expected sign. The relationship between SNF and butterfat varied from month-to-month with respect to how the constants (c) for the equations varied inversely with the butterfat coefficients (b). As is shown in Table A-3 (see Appendix), the constant of the regression equations ranged from approximately 6.82 to 7.28 while the butterfat coefficient ranged from 0.38 to 0.48 during the year (see also Appendix Figure A-6).

Table 4

Comparison of Regression Results: Butterfat Levels as a Predictor of SNF Levels

Study (Region and Year)	Equation
Upper Midwest (2000)	SNF = 7.00097% + 0.44840 (BF)
Upper Midwest (1999)	SNF = 7.13236% + 0.41482 (BF)
Upper Midwest (1998)	SNF = 7.10099% + 0.41530 (BF)
Upper Midwest (1997)	SNF = 6.95151% + 0.45570 (BF)
Upper Midwest (1996)	SNF = 7.01575% + 0.43459 (BF)
Upper Midwest (1995)	SNF = 7.07430% + 0.41700 (BF)
Mykrantz (Upper Midwest, 1994)	SNF = 7.20057% + 0.38175 (BF)
Mykrantz (Upper Midwest, 1993)	SNF = 7.04990% + 0.42228 (BF)
Halverson/Kyburz (Upper Midwest, 1986)	SNF = 6.97% + 0.4640 (BF)
Jack et al. (California, 1951)	SNF = 7.07% + 0.4440 (BF)
Jacobson (New England, 1930's)	SNF = 7.07% + 0.4000 (BF)

Protein Levels as a Predictor of SNF Levels

The regression equation, which uses protein levels to predict SNF levels, is written as:

$$SNF = c + b(PRO).$$

Comparisons were made with the results derived in each of the Upper Midwest Order studies and those derived by Halverson/Kyburz (see Table 5). The 1999 results were not appreciably different from the results for previous years.

Estimates for the relationship between protein and SNF on a monthly basis are presented in Table A-3 (see Appendix). Generally, these monthly regressions performed as expected, all parameters were statistically significant and of the expected sign. The R-squared statistics for the monthly regressions ranged from 0.63 to 0.73 and were very similar to those derived from the monthly data over the past three years. While the regressions did not show an identifiable seasonality, the constant and the protein coefficient varied inversely, i.e., when the constant rose, the protein coefficient fell, and vice versa. (See also Appendix Figure A-7).

Table 5

Comparison of Regression Results: Protein Levels as a Predictor of SNF Levels

Study (Region and Year)	Equation
Upper Midwest (2000)	SNF = 5.32439% + 1.04863 (PRO)
Upper Midwest (1999)	SNF = 5.27270% + 1.07108 (PRO)
Upper Midwest (1998)	SNF = 5.26469% + 1.06562 (PRO)
Upper Midwest (1997)	SNF = 5.10546% + 1.11637 (PRO)
Upper Midwest (1996)	SNF = 5.31567% + 1.04484 (PRO)
Upper Midwest (1995)	SNF = 5.26948% + 1.05511 (PRO)
Mykrantz (Upper Midwest, 1994)	SNF = 5.36198% + 1.03041 (PRO)
Mykrantz (Upper Midwest, 1993)	SNF = 5.16244% + 1.08507 (PRO)
Halverson/Kyburz (Upper Midwest, 1986)	SNF = 5.08% + 1.1138 (PRO)

Butterfat Levels as a Predictor of Protein Levels

The regression equation, which uses butterfat levels to predict protein levels, is written as:

$$PRO = c + b(BF).$$

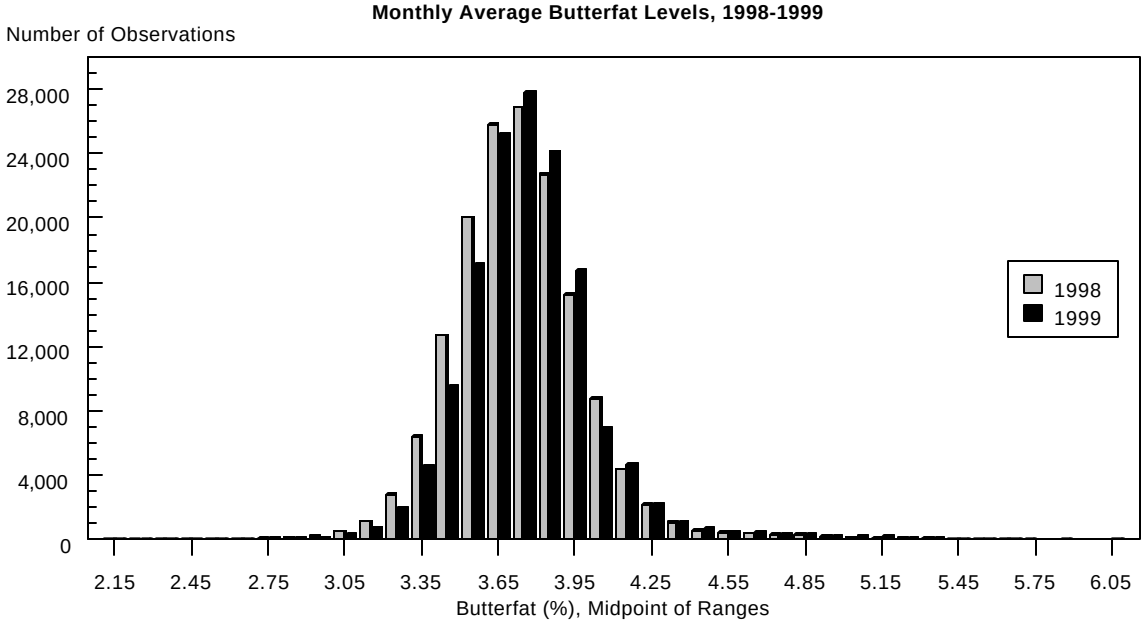
Comparisons were made between the results derived from the 1992 through 1999 data and those of Halverson/Kyburz (see Table 6). The primary observation from the equation derived for the 1999 data was that the *b* coefficient of 0.4342 was greater than the slopes in the equations from any of the eight previous studies. The steeper slope appears to be related to changes in the distributions of butterfat and protein levels for the market. In 1999, butterfat and protein levels were both more highly concentrated around their respective mean values and the distribution of butterfat tests was more positively skewed than in the previous year. Additionally, as reflected by the higher weighted average butterfat and protein levels for the market, a rightward shift can be observed in comparisons between 1998 and 1999 frequency distributions for butterfat and protein levels (see Figure 2).

Reasons for the observed differences in the 1999 data relative to previous years can not be determined from the data used in this analysis. However, several other factors may have contributed to these results. For example, from mid-1998 through 1999 dairy farmers experienced some very favorable cost-price[7] circumstances. The combination of lower feed costs and relatively higher milk prices may have encouraged the use of additional grain in

[7] In 1998, the milk-feed price ratio began to rise in May, for an average of 3.29 for the year and representing an increase of nearly 37% from 1997. In 1999, the milk-feed price ratio averaged 3.6, up nearly 9% from 1998. Source: Dairy Market News, USDA, *Dairy Market Statistics*, Annual Summaries for 1998 and 1999.

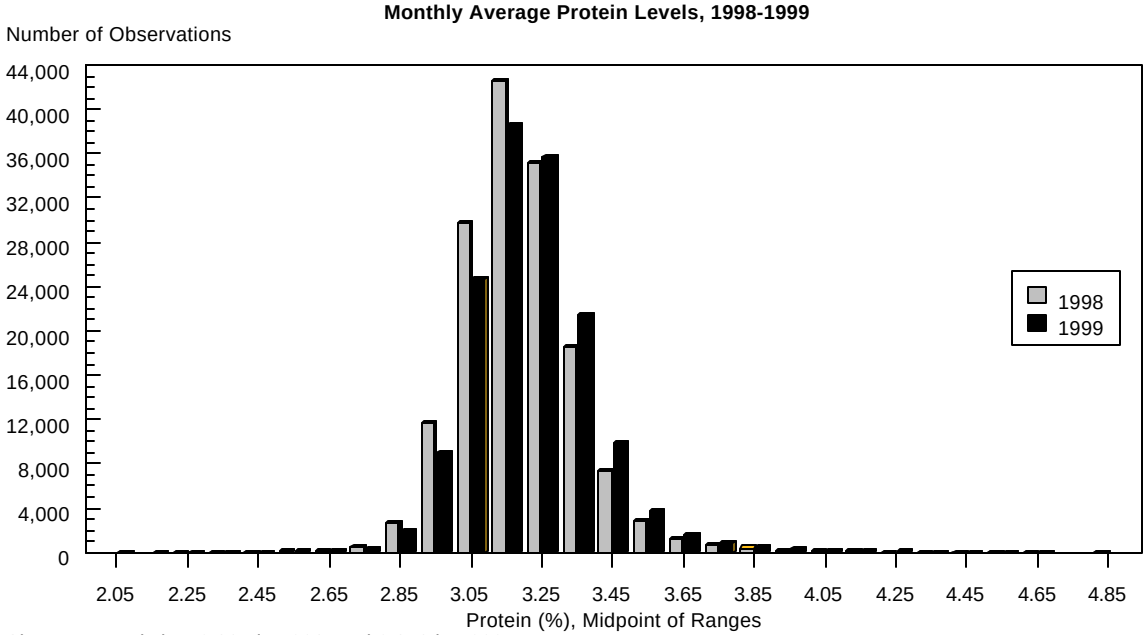
feed rations which tends to increase milk production and potentially, impact the relationship between butterfat and protein levels.

Figure 2
Frequency Distribution of
Monthly Average Butterfat Levels, 1998-1999



Skewness statistics: 0.859 in 1998, and 1.002 in 1999.
Kurtosis statistics: 4.012 in 1998, and 4.793 in 1999.

Frequency Distribution of
Monthly Average Protein Levels, 1998-1999



Skewness statistics: 0.827 in 1998, and 0.853 in 1999.
Kurtosis statistics: 2.987 in 1998, and 3.284 in 1999.

On a monthly basis, estimates of the relationship between butterfat and protein are shown in Table A-3 (see Appendix). The parameters of the monthly regressions were statistically significant and of the expected sign. The R-squared statistics for the monthly regressions ranged from 0.31 to 0.45, similar to those in the 1993 through 1999 studies. The equations showed seasonality with the constant and the butterfat coefficient varying inversely, i.e., when the constant rose, the butterfat coefficient fell, and vice versa. The constant in the monthly regressions rose from approximately 1.61 in January to 1.87 in May, then fell back to 1.61 by December. The butterfat coefficient fell from approximately 0.43 in January to 0.35 in May, then rose back to 0.43 by December. The pattern of change observed in butterfat coefficients was similar to the variation of the R-squared statistics for the monthly regressions. These results indicate that butterfat levels explain less of the variability in protein levels during the summer months than in the winter (see also Appendix Figure A-8).

Table 6

Comparison of Regression Results: Butterfat Levels as a Predictor of Protein Levels

Study (Region and Year)	Equation
Upper Midwest (2000)	PRO = 1.57404% + 0.43420 (BF)
Upper Midwest (1999)	PRO = 1.65909% + 0.40796 (BF)
Upper Midwest (1998)	PRO = 1.61984% + 0.41715 (BF)
Upper Midwest (1997)	PRO = 1.63183% + 0.41397 (BF)
Upper Midwest (1996)	PRO = 1.61375% + 0.41951 (BF)
Upper Midwest (1995)	PRO = 1.71454% + 0.39416 (BF)
Mykrantz (Upper Midwest, 1994)	PRO = 1.73836% + 0.38269 (BF)
Mykrantz (Upper Midwest, 1993)	PRO = 1.79012% + 0.37609 (BF)
Halverson/Kyburz (Upper Midwest, 1986)	PRO = 1.74% + 0.4042 (BF)

Other Solids Levels

During 1999, the other solids price on the Upper Midwest order was the residual value of the basic formula price after removing the value of the butterfat and protein. Pounds of other solids in producer milk were reported monthly to the Market Administrator from which the other solids content of milk was determined for the market and individual producers. As with butterfat and protein, other solids levels in producer milk were analyzed with respect to finding observable relationships with other components.

A comparison of correlation coefficients for other solids with butterfat and protein revealed that the statistical relationships are very weak at best. In contrast, the correlation coefficient for other solids and SNF of 0.61 suggests that a moderately strong linear relationship exists while protein and SNF appears to have a strong relationship with a coefficient of 0.83. These results, however, are not surprising due to the fact that SNF is the sum of the protein and other solids components.

Regression analysis was used to explore the use of butterfat and protein as predictors for other solids as was done in previous studies for predicting SNF. The results, like the correlation coefficients, show that neither butterfat nor protein are suitable predictors to estimate other solids levels. These results do show that the protein portion, rather than the other solids portion of SNF, is the more influential component in terms of estimating changes in the level of SNF in milk.

V. COMPONENT VALUES UNDER THE UPPER MIDWEST ORDER

Multiple component pricing on the Upper Midwest Order allows for component levels to be viewed in terms of the value of producer milk given its composition. Milk values, for the purpose of this study, were calculated on an annual basis using monthly Federal order component prices applied to producer milk associated with the Upper Midwest Order during 1999. These values reflect the aggregated value of butterfat, protein and other solids only. These values do not include monthly producer price differentials for the Upper Midwest Order or premiums and/or deductions that handlers pooling milk under the Order may apply to producer pay prices.

In 1999, the cumulative value of butterfat, protein, other solids and an adjustment for SCC averaged $12.687 per cwt. for the market. The value of each component comprised by the $12.687 per cwt. price was $4.872 for butterfat, $5.933 for protein, and $1.896 for the other solids. The SCC adjustment for the year amounted to about -$1.6 million, or -1.4¢ per cwt., from aggregated component values of $1.5 billion.

Categorized by size range of delivery, average values of producer milk ranged from a low of $12.52 per cwt. for monthly producer milk deliveries of more than 400,000 pounds to a high of $12.90 per cwt. for monthly producer milk deliveries of 20,000 to 30,000 pounds (see appendix Table A-5). In general, the average value of producer milk was greater for monthly deliveries of less than 100,000 pounds than for monthly deliveries greater than 100,000 pounds. These results correspond well to comparisons between mean and weighted average component levels in Part III of this paper.

VI. SUMMARY

This staff paper analyzes milk components and SCC in producer milk associated with the Upper Midwest Order during 1999. The data include component levels for butterfat, protein, other solids and SNF, and SCC. The study determined: average component levels and SCC, regional and seasonal differences in component levels and SCC, and relationships among components in individual herd milk at the farm level in the Upper Midwest Order milk procurement area. Also, component levels were analyzed on the basis of differing values based on milk composition under the MCP provisions of the market.

Weighted average component levels and SCC for 1999 were: 3.73% butterfat, 3.19% protein, 5.51% other solids, 8.70% SNF and 366,000 SCC. Weighted average butterfat, protein and SNF levels were lowest in July and highest in the late fall and winter. The weighted monthly average levels of other solids were highest in February through June and lowest in September and exhibited less variation during the year relative to the three other components. Weighted average SCC were lowest in December and highest in August. Approximately three-quarters of monthly average component levels ranged from: 3.50% to 4.02% for butterfat; 3.04% to 3.38% for protein; 5.36% to 5.60% for other solids; 8.47% to 8.90% for SNF; and 207,000 to 579,000 for SCC.

Based on the data for 1999, the following regression equations were derived:

$$SNF = 7.00\% + 0.4484\ (BF)$$
$$SNF = 5.32\% + 1.0486\ (PRO)$$
$$PRO = 1.57\% + 0.4342\ (BF)$$

Seasonality was present in comparisons made between the coefficients of most of the monthly regression equations. In comparisons with previous studies, small differences were observed between the estimates based on the 1999 data and those from previous Upper Midwest studies, Halverson/Kyburz, Jacobson and Jack et al.

Under MCP, the annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $12.69 per cwt. for the market. Protein contributed slightly less than half of the total value.

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APPENDIX

TABLES

FIGURES

Table A-1

STATISTICAL DATA FOR PRODUCERS ON THE UPPER MIDWEST ORDER INCLUDED IN COMPONENT ANALYSIS

1999

Butterfat

Month	Weighted Average - % -	Mean - % -	Standard Deviation - % -	Median - % -	Minimum - % -	Maximum - % -	Number of Observations (1,000)
January	3.81	3.85	0.26	3.83	2.53	5.89	12,752
February	3.77	3.81	0.25	3.79	2.40	5.84	12,752
March	3.77	3.81	0.25	3.79	2.19	5.82	12,720
April	3.75	3.78	0.24	3.77	2.35	5.55	12,700
May	3.69	3.72	0.24	3.71	2.30	5.46	12,614
June	3.63	3.65	0.23	3.64	2.38	5.63	12,533
July	3.58	3.59	0.22	3.58	2.36	5.12	12,533
August	3.59	3.61	0.23	3.61	2.26	5.20	12,456
September	3.70	3.74	0.23	3.73	2.34	5.87	12,372
October	3.82	3.86	0.25	3.85	2.21	5.64	11,825
November	3.82	3.87	0.26	3.86	2.26	6.04	11,896
December	3.82	3.86	0.26	3.85	2.27	6.04	11,814
For the Year	3.73	3.76	0.26	3.75	2.19	6.04	148,967

Protein

Month	Weighted Average - % -	Mean - % -	Standard Deviation - % -	Median % -	Minimum - % -	Maximum - % -	Number of Observations (1,000)
January	3.25	3.26	0.16	3.25	2.09	4.47	12,752
February	3.21	3.22	0.16	3.21	2.17	4.50	12,752
March	3.20	3.21	0.16	3.20	2.21	4.46	12,720
April	3.15	3.16	0.15	3.15	2.12	4.23	12,700
May	3.14	3.15	0.15	3.14	2.42	4.16	12,614
June	3.12	3.13	0.14	3.12	2.32	4.06	12,533
July	3.07	3.08	0.14	3.07	2.24	4.00	12,533
August	3.13	3.15	0.14	3.13	2.08	4.14	12,456
September	3.23	3.25	0.15	3.23	2.23	4.42	12,372
October	3.29	3.32	0.16	3.31	2.05	4.44	11,825
November	3.28	3.30	0.17	3.29	2.05	4.46	11,896
December	3.26	3.28	0.17	3.26	2.21	4.55	11,814
For the Year	3.19	3.21	0.17	3.19	2.05	4.55	148,967

Table A-1 (continued)

STATISTICAL DATA FOR PRODUCERS ON THE UPPER MIDWEST ORDER INCLUDED IN COMPONENT ANALYSIS

1999

Other Solids

Month	Weighted Average - % -	Mean - % -	Standard Deviation - % -	Median - % -	Minimum - % -	Maximum - % -	Number of Observations (1,000)
January	5.51	5.48	0.11	5.50	3.71	5.77	12,752
February	5.53	5.51	0.11	5.53	3.84	5.99	12,752
March	5.54	5.52	0.11	5.53	3.85	5.83	12,720
April	5.55	5.53	0.11	5.54	4.04	5.84	12,700
May	5.54	5.52	0.10	5.54	4.33	5.84	12,614
June	5.52	5.49	0.11	5.51	3.96	5.86	12,533
July	5.50	5.47	0.11	5.49	3.96	5.80	12,533
August	5.48	5.44	0.12	5.46	3.92	5.85	12,456
September	5.47	5.44	0.12	5.46	3.78	5.79	12,372
October	5.49	5.45	0.13	5.47	3.54	5.98	11,825
November	5.48	5.44	0.13	5.46	3.58	5.80	11,896
December	5.49	5.46	0.12	5.48	3.71	6.05	11,814
For the Year	5.51	5.49	0.12	5.50	3.54	6.05	148,967

Solids-Not-Fat

Month	Weighted Average - % -	Mean - % -	Standard Deviation - % -	Median - % -	Minimum - % -	Maximum - % -	Number of Observations (1,000)
January	8.76	8.74	0.21	8.75	5.81	9.89	12,752
February	8.74	8.73	0.21	8.74	6.08	9.97	12,752
March	8.74	8.73	0.20	8.73	6.06	9.86	12,720
April	8.71	8.69	0.20	8.70	6.16	9.59	12,700
May	8.68	8.68	0.19	8.68	6.89	9.59	12,614
June	8.63	8.62	0.20	8.63	6.57	9.57	12,533
July	8.57	8.55	0.21	8.56	6.20	9.47	12,533
August	8.61	8.59	0.21	8.60	6.14	9.48	12,456
September	8.70	8.69	0.20	8.70	6.05	9.64	12,372
October	8.78	8.77	0.21	8.77	5.59	9.77	11,825
November	8.76	8.75	0.21	8.75	5.63	9.85	11,896
December	8.75	8.74	0.21	8.74	5.99	9.88	11,814
For the Year	8.70	8.69	0.22	8.70	5.59	9.97	148,967

Table A-1 (continued)

STATISTICAL DATA FOR PRODUCERS ON THE UPPER MIDWEST ORDER INCLUDED IN COMPONENT ANALYSIS

1999

Somatic Cell Count

Month	Weighted Average	Mean	Standard Deviation	Median	Minimum	Maximum	Number of Observations
	(1,000)						
January	344	370	185	336	19	1,432	12,752
February	357	384	191	351	19	1,500	12,752
March	349	377	183	347	21	1,430	12,720
April	354	382	183	351	26	1,500	12,700
May	359	385	179	356	20	1,440	12,614
June	382	407	180	380	41	1,473	12,533
July	412	440	192	411	39	1,500	12,533
August	445	473	201	447	37	1,448	12,456
September	398	421	182	393	26	1,401	12,372
October	341	363	166	335	26	1,338	11,825
November	329	354	171	324	22	1,468	11,896
December	328	358	175	326	24	1,423	11,814
For the Year	366	393	186	363	19	1,500	148,967

Table A-2

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY REGION
1999

Butterfat

	Region 1 - % -	No. *	Region 2 - % -	No. *	Region 3 - % -	No. *	Region 4 - % -	No. *	Region 5 - % -	No. *	Region 6 - % -	No. *	Mkt. - % -
January	3.87	2,608	3.81	7,312	3.82	695	3.75	1,597	3.78	239	3.78	301	3.81
February	3.83	2,607	3.76	7,309	3.76	697	3.72	1,599	3.72	241	3.74	299	3.77
March	3.84	2,578	3.76	7,310	3.76	693	3.72	1,594	3.71	243	3.75	302	3.77
April	3.81	2,565	3.74	7,314	3.72	697	3.71	1,592	3.66	241	3.76	291	3.75
May	3.75	2,549	3.68	7,252	3.66	699	3.66	1,572	3.55	246	3.65	296	3.69
June	3.68	2,520	3.63	7,223	3.60	699	3.60	1,559	3.51	239	3.58	293	3.63
July	3.60	2,507	3.57	7,240	3.57	697	3.57	1,553	3.51	237	3.54	299	3.58
August	3.63	2,492	3.58	7,206	3.57	685	3.57	1,546	3.52	230	3.53	297	3.59
September	3.73	2,465	3.70	7,165	3.71	687	3.70	1,537	3.66	224	3.71	294	3.70
October	3.85	2,439	3.81	6,697	3.81	611	3.80	1,557	3.77	223	3.82	298	3.82
November	3.87	2,425	3.82	6,749	3.80	661	3.79	1,547	3.80	221	3.82	293	3.82
December	3.87	2,416	3.82	6,701	3.82	640	3.78	1,542	3.79	225	3.83	290	3.82
For the Year	3.78	30,171	3.72	85,478	3.71	8,161	3.70	18,795	3.66	2,809	3.71	3,553	3.73

Protein

	Region 1 - % -	No. *	Region 2 - % -	No. *	Region 3 - % -	No. *	Region 4 - % -	No. *	Region 5 - % -	No. *	Region 6 - % -	No. *	Mkt. - % -
January	3.27	2,608	3.24	7,312	3.25	695	3.24	1,597	3.28	239	3.28	301	3.25
February	3.22	2,607	3.20	7,309	3.21	697	3.21	1,599	3.24	241	3.23	299	3.21
March	3.21	2,578	3.19	7,310	3.20	693	3.20	1,594	3.21	243	3.21	302	3.20
April	3.17	2,565	3.15	7,314	3.16	697	3.15	1,592	3.14	241	3.16	291	3.15
May	3.16	2,549	3.13	7,252	3.15	699	3.15	1,572	3.11	246	3.14	296	3.14
June	3.12	2,520	3.11	7,223	3.12	699	3.13	1,559	3.12	239	3.10	293	3.12
July	3.07	2,507	3.06	7,240	3.07	697	3.09	1,553	3.09	237	3.06	299	3.07
August	3.14	2,492	3.13	7,206	3.13	685	3.14	1,546	3.14	230	3.11	297	3.13
September	3.24	2,465	3.22	7,165	3.24	687	3.24	1,537	3.25	224	3.23	294	3.23
October	3.31	2,439	3.29	6,697	3.31	611	3.30	1,557	3.33	223	3.30	298	3.29
November	3.30	2,425	3.27	6,749	3.29	661	3.29	1,547	3.29	221	3.28	293	3.28
December	3.28	2,416	3.25	6,701	3.26	640	3.26	1,542	3.26	225	3.27	290	3.26
For the Year	3.21	30,171	3.19	85,478	3.20	8,161	3.20	18,795	3.20	2,809	3.20	3,553	3.19

* Number of producers with monthly average component levels.

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY REGION
1999

Other Solids

	Region 1	No. *	Region 2	No. *	Region 3	No. *	Region 4	No. *	Region 5	No. *	Region 6	No. *	Mkt.
	- % -		- % -		- % -		- % -		- % -		- % -		% -
January	5.47	2,608	5.51	7,312	5.52	695	5.54	1,597	5.54	239	5.53	301	5.51
February	5.49	2,607	5.54	7,309	5.55	697	5.57	1,599	5.55	241	5.57	299	5.53
March	5.49	2,578	5.54	7,310	5.55	693	5.58	1,594	5.54	243	5.57	302	5.54
April	5.52	2,565	5.55	7,314	5.57	697	5.58	1,592	5.57	241	5.59	291	5.55
May	5.52	2,549	5.54	7,252	5.55	699	5.57	1,572	5.59	246	5.57	296	5.54
June	5.48	2,520	5.52	7,223	5.53	699	5.54	1,559	5.56	239	5.55	293	5.52
July	5.48	2,507	5.50	7,240	5.52	697	5.52	1,553	5.53	237	5.52	299	5.50
August	5.45	2,492	5.48	7,206	5.49	685	5.50	1,546	5.50	230	5.50	297	5.48
September	5.44	2,465	5.48	7,165	5.48	687	5.49	1,537	5.49	224	5.49	294	5.47
October	5.46	2,439	5.49	6,697	5.49	611	5.50	1,557	5.49	223	5.50	298	5.49
November	5.44	2,425	5.49	6,749	5.50	661	5.49	1,547	5.49	221	5.52	293	5.48
December	5.46	2,416	5.50	6,701	5.51	640	5.50	1,542	5.52	225	5.52	290	5.49
For the Year	5.48	30,171	5.51	85,478	5.52	8,161	5.53	18,795	5.53	2,809	5.53	3,553	5.51

Solids-Not-Fat

	Region 1	No. *	Region 2	No. *	Region 3	No. *	Region 4	No. *	Region 5	No. *	Region 6	No. *	Mkt.
	- % -		- % -		- % -		- % -		- % -		- % -		- % -
January	8.73	2,608	8.76	7,312	8.77	695	8.78	1,597	8.82	239	8.81	301	8.76
February	8.71	2,607	8.74	7,309	8.76	697	8.78	1,599	8.79	241	8.80	299	8.74
March	8.71	2,578	8.74	7,310	8.75	693	8.78	1,594	8.75	243	8.78	302	8.74
April	8.69	2,565	8.70	7,314	8.73	697	8.74	1,592	8.72	241	8.75	291	8.71
May	8.68	2,549	8.68	7,252	8.70	699	8.72	1,572	8.70	246	8.71	296	8.68
June	8.61	2,520	8.63	7,223	8.64	699	8.67	1,559	8.68	239	8.65	293	8.63
July	8.55	2,507	8.56	7,240	8.59	697	8.60	1,553	8.62	237	8.58	299	8.57
August	8.60	2,492	8.61	7,206	8.62	685	8.64	1,546	8.64	230	8.61	297	8.61
September	8.68	2,465	8.70	7,165	8.72	687	8.74	1,537	8.74	224	8.72	294	8.70
October	8.77	2,439	8.78	6,697	8.80	611	8.80	1,557	8.82	223	8.80	298	8.78
November	8.74	2,425	8.76	6,749	8.79	661	8.78	1,547	8.78	221	8.80	293	8.76
December	8.74	2,416	8.75	6,701	8.77	640	8.76	1,542	8.78	225	8.78	290	8.75
For the Year	8.68	30,171	8.70	85,478	8.72	8,161	8.73	18,795	8.74	2,809	8.73	3,553	8.70

* Number of producers with monthly average component levels.

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY REGION
1999

Somatic Cell Counts

	Region 1 (1,000)	No. *	Region 2 (1,000)	No. *	Region 3 (1,000)	No. *	Region 4 (1,000)	No. *	Region 5 (1,000)	No. *	Region 6 (1,000)	No. *	Market (1,000)
January	343	2,608	346	7,312	341	695	346	1,597	315	239	333	301	344
February	360	2,607	359	7,309	353	697	358	1,599	317	241	339	299	357
March	352	2,578	349	7,310	345	693	351	1,594	325	243	327	302	349
April	350	2,565	356	7,314	350	697	354	1,592	334	241	333	291	354
May	352	2,549	361	7,252	359	699	364	1,572	339	246	345	296	359
June	381	2,520	383	7,223	392	699	386	1,559	338	239	362	293	382
July	407	2,507	414	7,240	415	697	418	1,553	369	237	398	299	412
August	440	2,492	447	7,206	460	685	445	1,546	376	230	424	297	445
September	392	2,465	402	7,165	397	687	406	1,537	346	224	370	294	398
October	336	2,439	344	6,697	333	611	348	1,557	309	223	306	298	341
November	321	2,425	335	6,749	318	661	334	1,547	286	221	286	293	329
December	329	2,416	332	6,701	320	640	328	1,542	282	225	286	290	328
For the Year	364	30,171	369	85,478	365	8,161	369	18,795	328	2,809	342	3,553	366

***** Number of producers with monthly average component levels.

Table A-3

LINEAR RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

1999

Butterfat Levels as a Predictor of Solids-Not-Fat Levels

SNF = c + b(BF)

Month	c Constant	B Butterfat Coefficient	Standard Error of **b**	R-squared (Adjusted)	Standard Error	Number of Comparisons
January	7.12358	0.42058	0.00613	0.26949	0.17729	12,752
February	7.18813	0.40488	0.00636	0.24099	0.17936	12,752
March	7.23169	0.39203	0.00647	0.22406	0.17984	12,720
April	7.12939	0.41284	0.00673	0.22856	0.17958	12,700
May	7.27920	0.37548	0.00650	0.20919	0.17269	12,614
June	7.12909	0.40887	0.00684	0.22181	0.17293	12,533
July	6.81770	0.48220	0.00733	0.25674	0.17814	12,533
August	7.07758	0.41897	0.00725	0.21129	0.18230	12,456
September	7.14373	0.41266	0.00690	0.22434	0.17984	12,372
October	7.15396	0.41775	0.00662	0.25191	0.18158	11,825
November	7.15025	0.41220	0.00645	0.25540	0.18445	11,896
December	7.11007	0.42094	0.00629	0.27496	0.17891	11,814
For the Year	7.00097	0.44840	0.00180	0.29483	0.18088	148,967

Protein Levels as a Predictor of Solids-Not-Fat Levels

SNF = c + b(PRO)

Month	c Constant	B Protein Coefficient	Standard Error of **b**	R-squared (Adjusted)	Standard Error	Number of Comparisons
January	5.26471	1.06660	0.00615	0.70216	0.11321	12,752
February	5.22748	1.08715	0.00630	0.70049	0.11267	12,752
March	5.15085	1.11384	0.00623	0.71529	0.10894	12,720
April	5.01657	1.16266	0.00634	0.72615	0.10699	12,700
May	5.06870	1.14392	0.00615	0.73271	0.10040	12,614
June	4.90227	1.18874	0.00665	0.71862	0.10398	12,533
July	4.74676	1.23578	0.00689	0.71951	0.10943	12,533
August	4.84945	1.18929	0.00736	0.67711	0.11664	12,456
September	5.17717	1.07999	0.00739	0.63327	0.12366	12,372
October	5.38491	1.01874	0.00724	0.62637	0.12833	11,825
November	5.42061	1.00687	0.00693	0.63932	0.12837	11,896
December	5.40377	1.01720	0.00661	0.66743	0.12117	11,814
For the Year	5.32439	1.04863	0.00183	0.68775	0.12036	148,967

Table A-3 (continued)

LINEAR RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

1999

Butterfat Levels as a Predictor of Protein Levels

PRO = c + b(BF)

Month	**c** Constant	**B** Butterfat Coefficient	Standard Error of **b**	R-squared (Adjusted)	Standard Error	Number of Comparisons
January	1.60988	0.42887	0.00416	0.45405	0.12041	12,752
February	1.64124	0.41505	0.00426	0.42734	0.11994	12,752
March	1.68407	0.40028	0.00430	0.40519	0.11956	12,720
April	1.67769	0.39196	0.00441	0.38357	0.11765	12,700
May	1.86846	0.34543	0.00452	0.31622	0.12016	12,614
June	1.85099	0.35005	0.00456	0.31974	0.11530	12,533
July	1.68217	0.38843	0.00469	0.35362	0.11403	12,533
August	1.87230	0.35261	0.00468	0.31266	0.11775	12,456
September	1.81681	0.38319	0.00463	0.35631	0.12072	12,372
October	1.71160	0.41651	0.00455	0.41496	0.12475	11,825
November	1.63745	0.43014	0.00444	0.44106	0.12691	11,896
December	1.61287	0.43053	0.00442	0.44594	0.12561	11,814
For the Year	1.57404	0.43420	0.00126	0.44199	0.12725	148,967

Coefficients for Month Variables in Equations for 1999

	(**m** month coefficients)		
Month **	SNF=c+b(BF)	SNF=c+b(PRO)	PRO=c+b(BF)
February	0.00497	0.03029	-0.02255
March	*	0.03950	-0.03592
April	-0.02346	0.05894	-0.07387
May	-0.01250	0.05151	-0.05880
June	-0.03808	0.02428	-0.05285
July	-0.08605	0.00885	-0.08106
August	-0.05293	-0.02532	-0.02049
September	-0.00971	-0.04370	0.03267
October	0.02000	-0.04083	0.05447
November	-0.00516	-0.04294	0.03331
December	-0.01156	-0.02343	0.00997

* Not all months entered into the final equations due to lack of statistical significance.

** January was excluded as a dummy variable to provide a base line for comparison. Including January does not provide additional information to the analysis that is not provided by the other eleven months.

Table A-4

MONTHLY COMPONENT PRICES AND SOMATIC CELL ADJUSTMENT RATES FOR THE UPPER MIDWEST ORDER

1999

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	($/Pound)			($/cwt. Per 1,000 SCC)
January	$1.4848	$2.3225	$0.6427	$0.00088
February	1.4441	1.6072	0.0000	0.00065
March	1.3900	1.7281	0.2239	0.00065
April	1.0349	1.7333	0.4860	0.00066
May	1.1838	1.6713	0.3335	0.00063
June	1.6679	1.6826	0.0468	0.00064
July	1.4290	1.9407	0.4859	0.00074
August	1.4703	2.2721	0.6708	0.00086
September	1.3785	2.3790	0.6901	0.00090
October	1.1764	1.8992	0.1796	0.00072
November	1.1305	1.6029	0.0876	0.00061
December	0.9262	1.4941	0.2700	0.00057
Simple Average	$1.3097	$1.8611	$0.3431	$0.00071

Table A-5

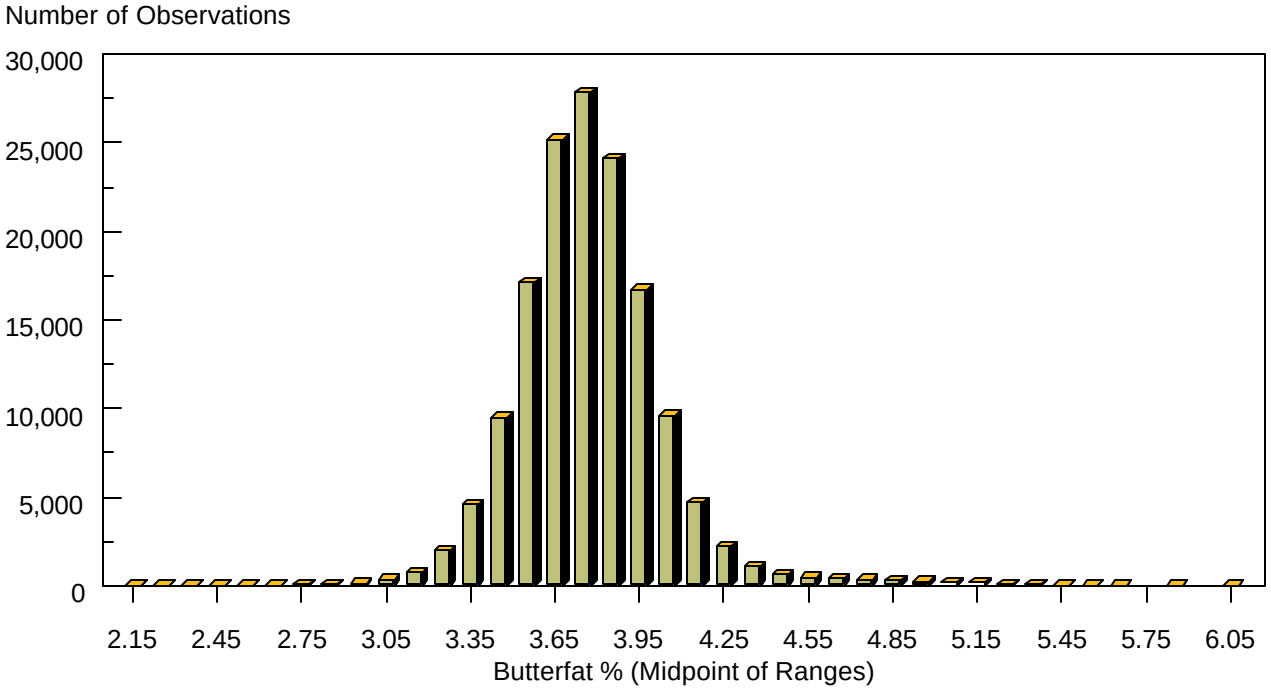
AGGREGATED COMPONENT VALUES BY SIZE RANGE OF MONTHLY PRODUCER MILK DELIVERIES

1999

Size Range		Aggregated Component Values*	Producer Milk	Weighted Average Value
Equal to or more than (Pounds)	Less than	($)	(Pounds)	($/Cwt.)
	20,000	$32,822,876.79	255,786,128	$12.832
20,000	30,000	34,525,767.60	267,667,447	12.899
30,000	50,000	136,248,814.82	1,065,390,382	12.788
50,000	70,000	196,368,327.24	1,541,331,916	12.740
70,000	100,000	284,685,528.97	2,239,801,907	12.710
100,000	150,000	287,690,641.87	2,270,773,305	12.669
150,000	250,000	216,818,996.60	1,708,374,771	12.692
250,000	400,000	101,176,188.01	797,808,163	12.682
400,000		222,520,693.59	1,777,241,817	12.521
Total		$1,512,857,835.49	11,924,175,836	
Weighted Average				$12.687

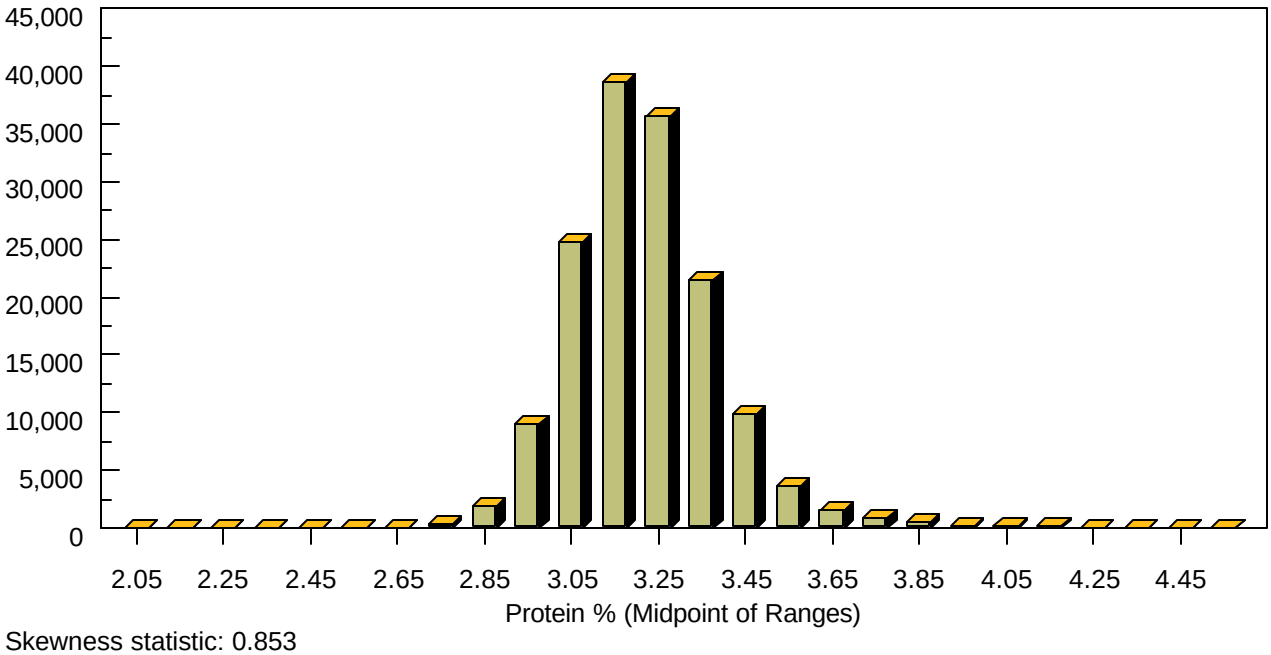
* Total value of pounds of butterfat, protein, and other solids adjusted for SCC.

Figure A-1
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE BUTTERFAT LEVELS, 1999



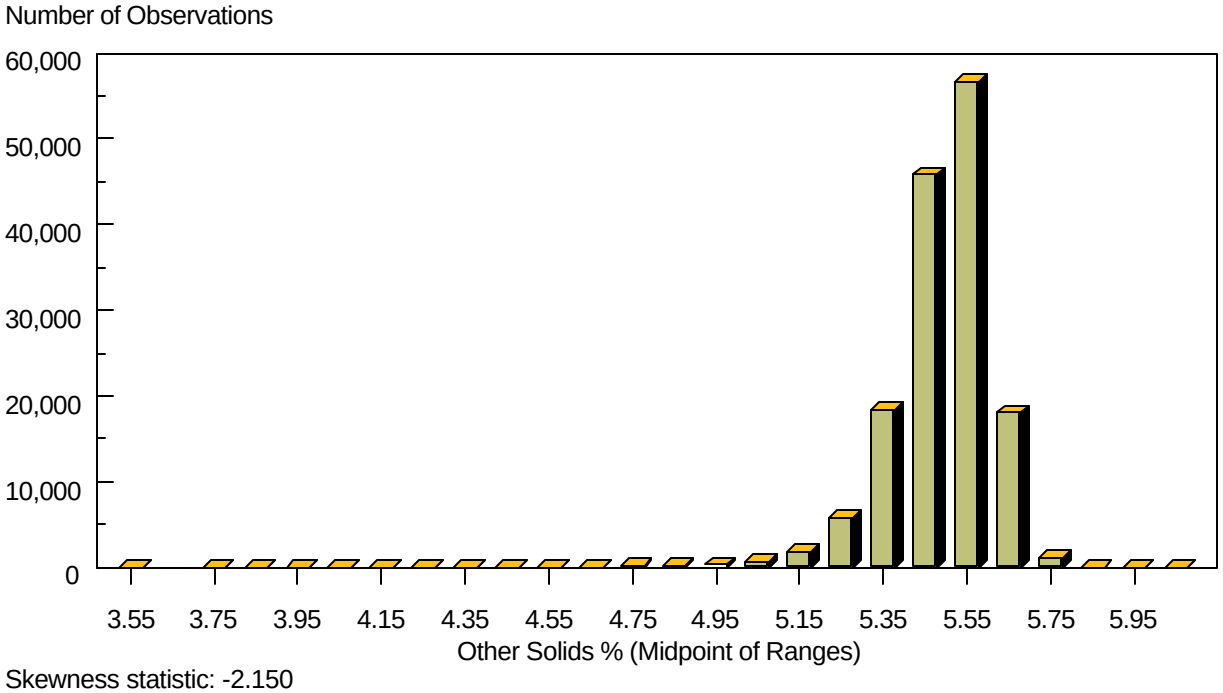
Skewness statistic: 1.002
Kurtosis statistic: 4.793

Figure A-2
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE PROTEIN LEVELS, 1999



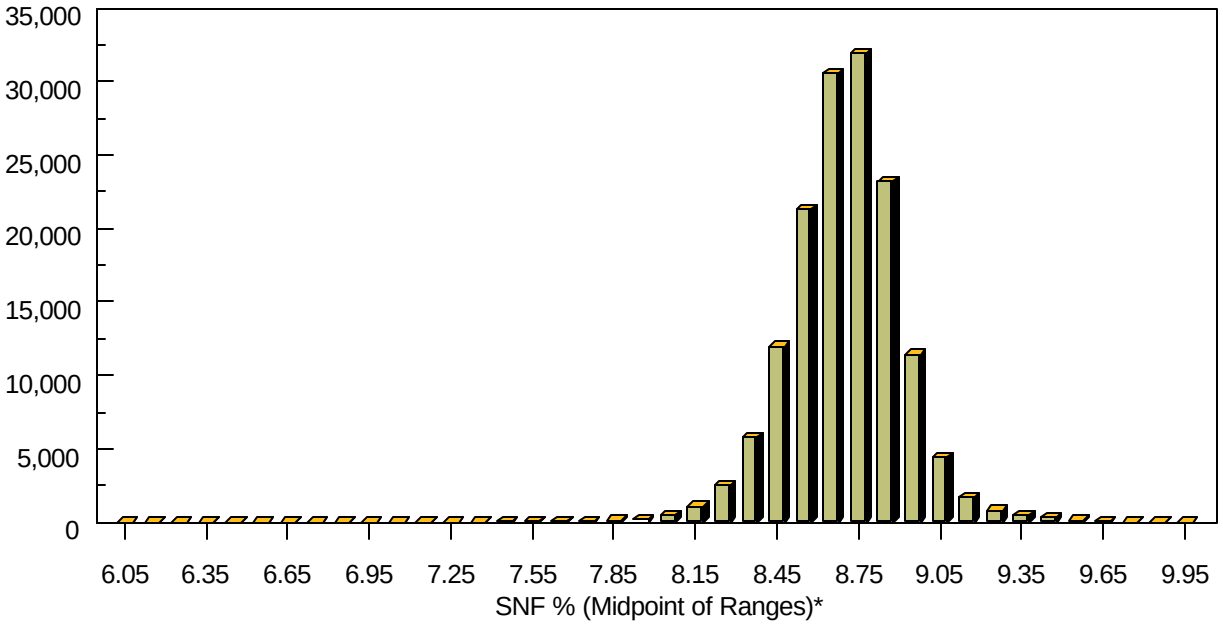
Skewness statistic: 0.853
Kurtosis statistic: 3.284

Figure A-3
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE OTHER SOLIDS LEVELS, 1999



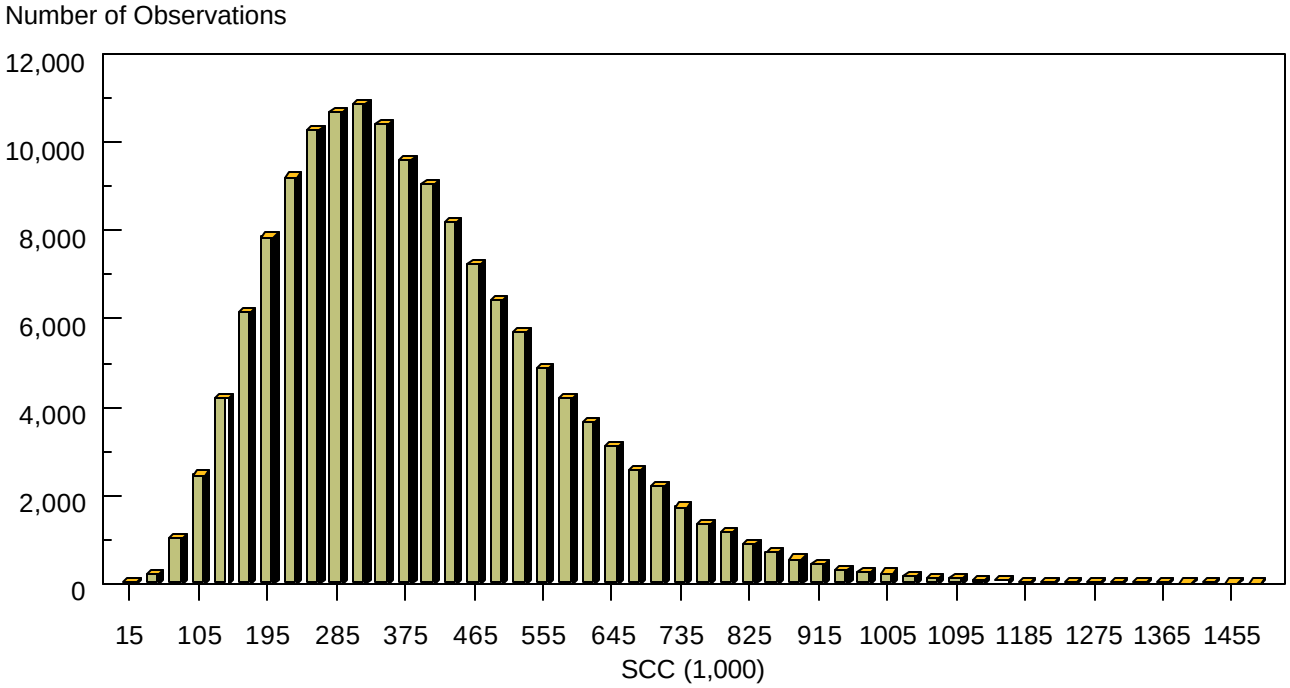
Skewness statistic: -2.150
Kurtosis statistic: 15.287

Figure A-4
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOLIDS-NOT-FAT LEVELS, 1999



Skewness statistic: -0.807
Kurtosis statistic: 8.658
* Several maximum values were not graphically represented in Figure A-4.

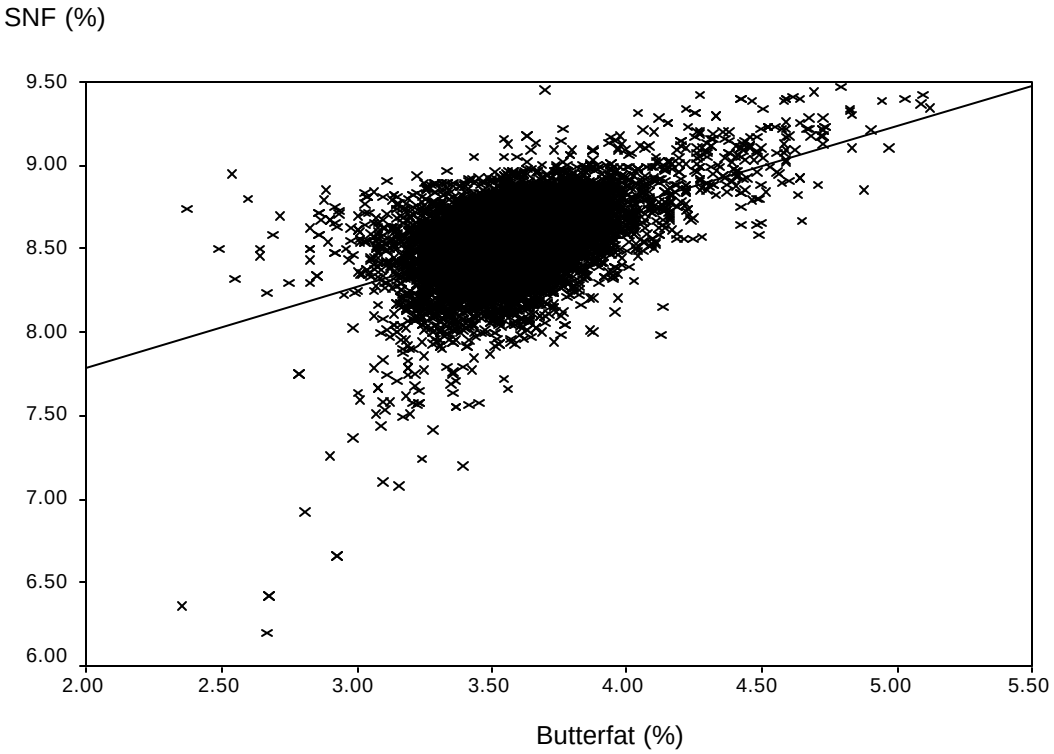
Figure A-5
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOMATIC CELL COUNT, 1999



Skewness statistic: 0.974
Kurtosis statistic: 1.454

Figure A-6
SCATTERPLOT OF SOLIDS-NOT-FAT AND BUTTERFAT
JULY AND NOVEMBER 1999

July (12,533 observations: SNF = 6.81770 + 0.48220 (Butterfat))



November (11,896 observations: SNF = 7.15025 + 0.41220 (Butterfat))

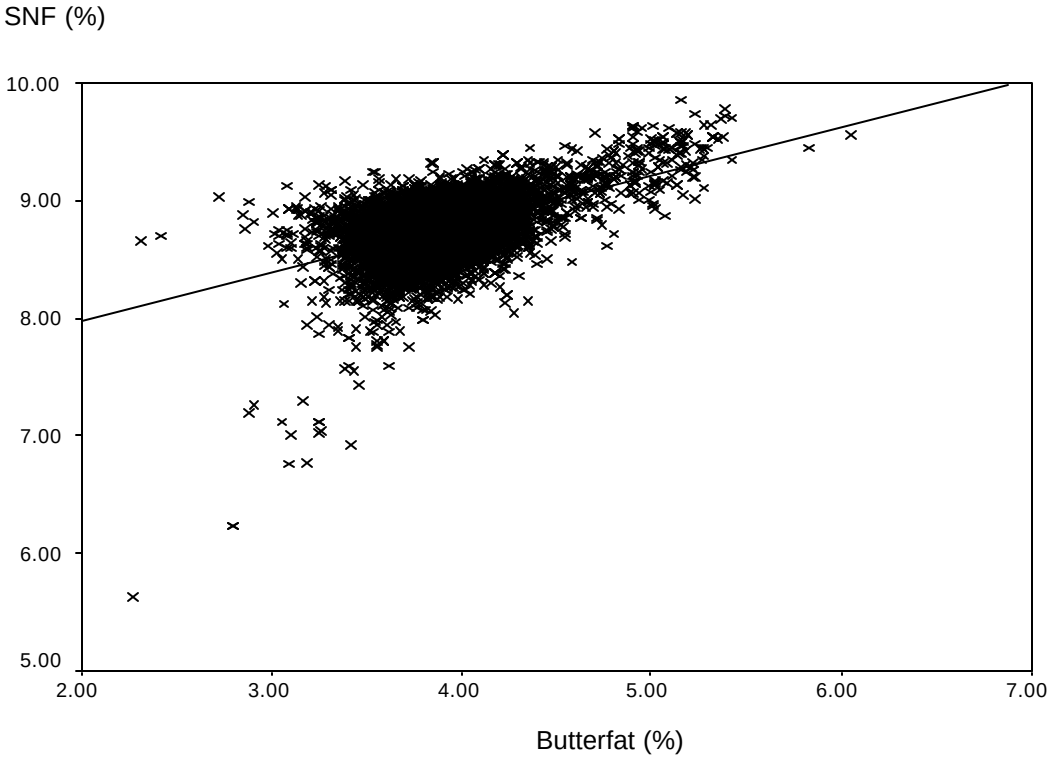
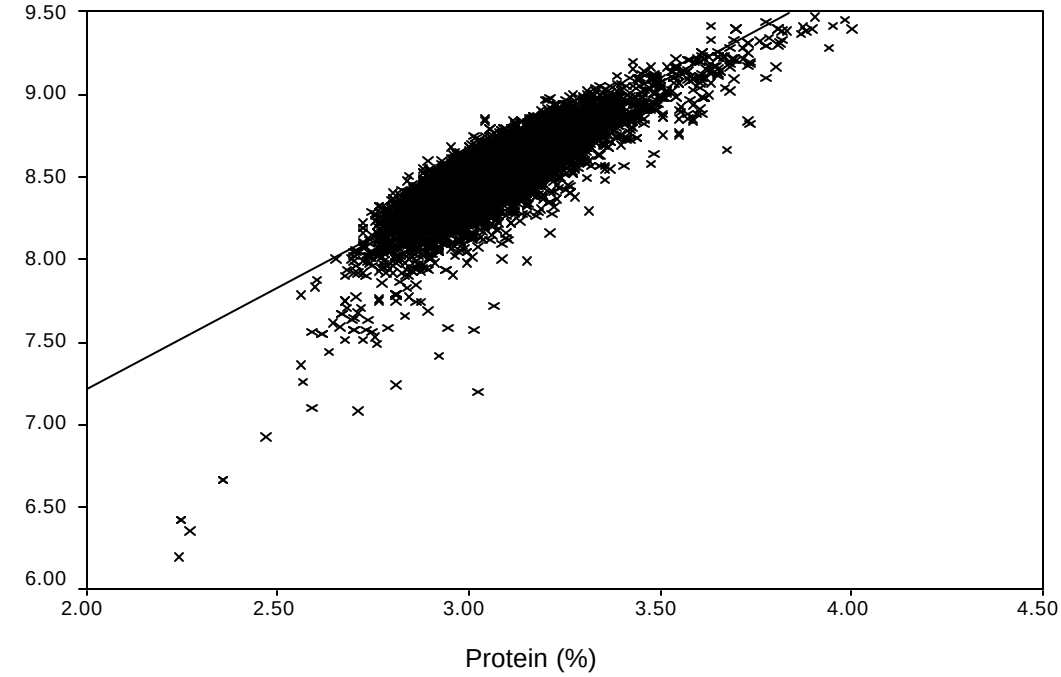


Figure A-7
SCATTERPLOT OF SOLIDS-NOT-FAT AND PROTEIN
JULY AND NOVEMBER 1999

July (12,533 observations: SNF = 4.74676 + 1.23578 (Protein))



November (11,896 observations: SNF = 5.42061 + 1.00687 (Protein))

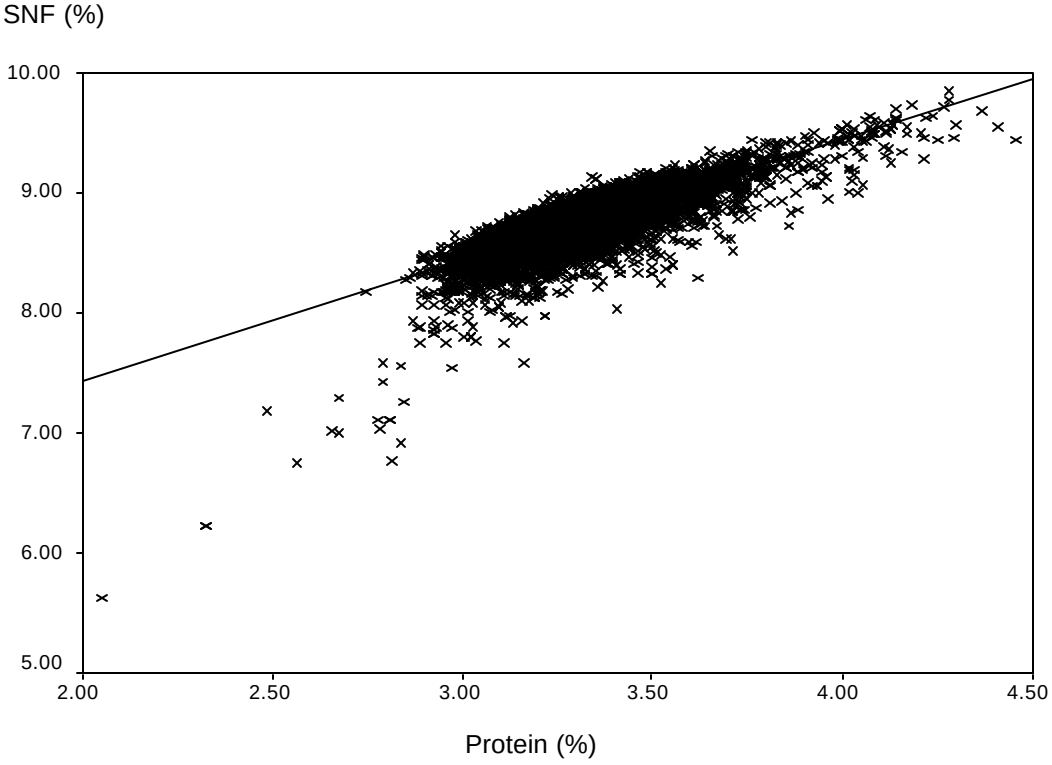
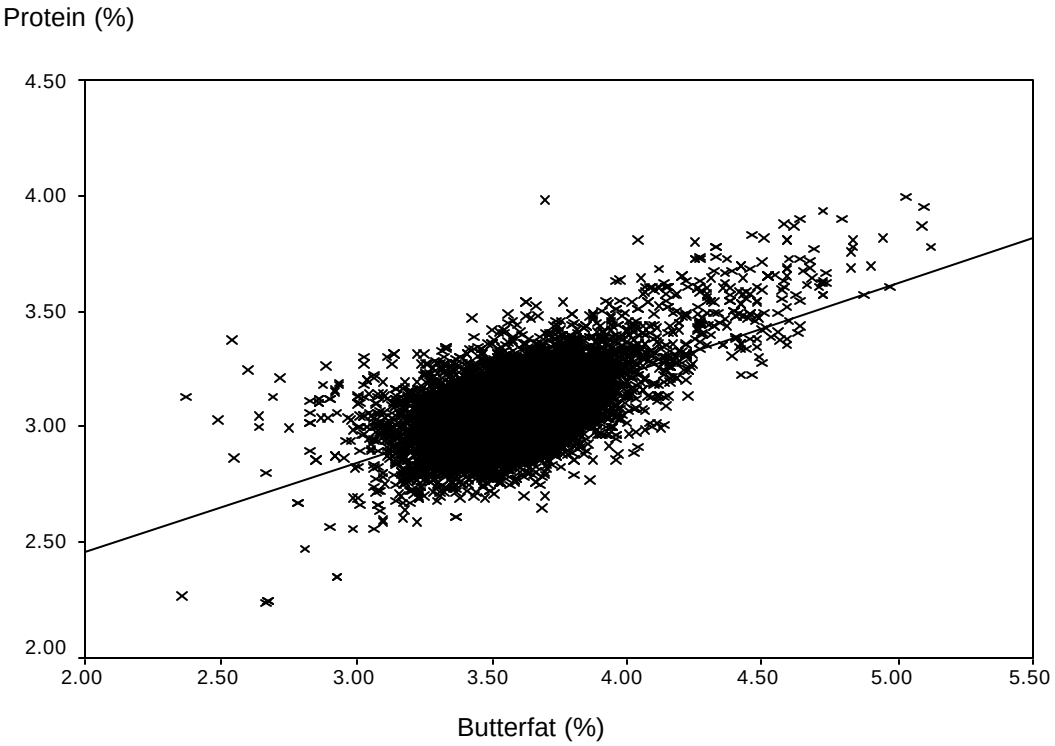


Figure A-8
SCATTERPLOT OF PROTEIN AND BUTTERFAT
JULY AND NOVEMBER 1999

July (12,533 observations: Protein = 1.68217 + 0.38843 (Butterfat))



November (11,896 observations: Protein = 1.63745 + 0.43014 (Butterfat))