UPPER MIDWEST MARKETING AREA

ANALYSIS OF COMPONENT LEVELS AND SOMATIC CELL COUNT IN INDIVIDUAL HERD MILK AT THE FARM LEVEL 2004

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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 2004. Results from the analysis include: market and state averages and seasonal variation in component levels and SCC, and statistical relationships among the four components in individual herd milk at the farm level.

In this study, component prices from 2004 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 2004 were 3.72% butterfat, 3.03% protein, 5.71% other solids, 8.74% SNF and 289,000 SCC.

2) For 2004, weighted average butterfat, protein, and SNF levels were lowest in July and highest during the early fall and winter. In contrast, other solids levels varied little during the year. Weighted average SCC were lowest in the fall and early winter and highest in July and August.

3) Butterfat, protein, and SCC tests declined with increasing monthly average milk production, while other solids and solids-not-fat tests increased with increasing monthly milk production.

4) In 2004, the range of weighted average component levels within one standard deviation of the mean was: 3.48% to 3.96% for butterfat; 2.89% to 3.17% for protein; 5.60% to 5.82% for other solids; 8.56% to 8.92% for SNF; and 149,000 to 429,000 for SCC.

5) Based on the data for 2004, the following regression equations were derived:

$$SNF = 7.21824\% + 0.39023\ (BF)$$
$$SNF = 5.41126\% + 1.08236\ (PRO)$$
$$PRO = 1.59839\% + 0.37888\ (BF)$$

5) The annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $16.03 per cwt. for the market in 2004. Protein was the most valuable component, contributing slightly more than one-half of the total value.

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I. INTRODUCTION

The data for this study were collected for milk marketed in 2004 from producers associated with the Upper Midwest Milk Marketing Order. The former Chicago Regional and Upper Midwest Orders were combined on January 1, 2000 as part of the milk order reform required by the 1996 Farm Bill. Geographically, the Upper Midwest Order now includes nearly all of Minnesota and Wisconsin and portions of the Dakotas, Illinois, Iowa and the Michigan Upper Peninsula. Multiple component pricing (MCP), initially adopted in the region in 1996, continued to be the basis for establishing the value of milk pooled under the new order. Under the current MCP plan, producer milk is priced on the cumulative value of butterfat, protein and other solids[2] pounds with adjustments for somatic cell count (SCC) levels. Prior to the introduction of MCP, earlier studies on component levels in individual herd milk were conducted for a sample of producers on the former Upper Midwest Order. In those studies, butterfat, protein, lactose, solids-not-fat (SNF) levels and SCC in milk were analyzed to determine: average component levels, regional and seasonal variation in component levels and SCC, and statistical relationships between the four components in individual herd milk at the farm level. Since MCP has been in effect for payments on producer milk under the order, monthly payroll records for producers associated with the Upper Midwest Order were used to determine monthly and annual average: butterfat, protein[3], other solids and solids-not-fat levels and SCC. Differences between states and seasonal variations of component levels and SCC were noted and analyses were conducted to evaluate the strength of relationships among components.

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[1] The author, Dr. Corey Freije, is an Agricultural Economist with the Market Administrator's Office, Minneapolis, Minnesota. Assisting Dr. Freije were Rachel M. Benecke and Henry Schaefer of the Upper Midwest Market Administrator's office.

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

[3] Protein tests for 2004 reflect the change from crude protein to true protein testing methods that occurred in January 2000. The difference between crude and true protein levels in milk is non-protein nitrogen (NPN). On an absolute basis, NPN accounts for about 0.19 percentage points of the "protein" in a crude protein value.

II. DATA AND METHODOLOGY

The data used in this analysis are from monthly payroll records submitted to the Upper Midwest Order. Since handlers generally submit their entire payrolls, the data includes not only producer milk pooled on the Upper Midwest, but also may include, in some cases, producer milk pooled on other orders and milk historically associated with the order but not pooled in some months because of price relationships between classes and other Federal marketing orders. The result is a significant difference between the number of producers and milk production reported in this study and the number of producers and milk production reported as pooled on the Upper Midwest Order. 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 individual producers, total monthly milk marketed, component pounds and SCC from payrolls submitted to the Market Administrator's office were aggregated to the farm level for this analysis. All producer milk was included in the analysis that 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.[4] In addition, component levels were examined for the seven primary states that are at least partially within the milk procurement area of the Upper Midwest Order and for the State of Idaho. Since the procurement area stretches from south of Chicago to northwestern North Dakota, state level component and SCC statistics provide a means of reflecting variation in milk composition across a large geographic area. For 2004, average component levels by size of producer marketings were also examined.

Ordinary Least Square (OLS) regression analysis was used to determine the relationship between individual components as well as the impact of seasonality on component tests, 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.

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4 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 VARIATION IN MILK COMPONENT LEVELS AND SOMATIC CELL COUNT

Seasonal changes in component levels for 2004 appeared to be relatively "normal". Beginning in January, butterfat and protein tests tapered off during the spring to low points in July, then rose to peak levels at some time in the late fall or winter. Other solids tests increased slightly in the spring and then declined slightly and leveled off for the remainder of the year. 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 2004 are summarized in Table 1 and miscellaneous annual statistics, in addition to weighted averages, are summarized in Table 2.

Table 1

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

2004

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.80	3.07	5.72	8.79	280
February	3.80	3.06	5.70	8.75	291
March	3.75	3.02	5.71	8.73	300
April	3.71	3.01	5.71	8.72	295
May	3.68	2.99	5.72	8.71	290
June	3.63	2.97	5.72	8.69	308
July	3.60	2.95	5.71	8.66	322
August	3.63	2.99	5.72	8.71	317
September	3.67	3.02	5.71	8.74	291
October	3.77	3.10	5.69	8.79	263
November	3.81	3.11	5.68	8.79	255
December	3.80	3.10	5.68	8.78	255
Mean	3.72	3.03	5.71	8.74	289
Minimum	3.60	2.95	5.68	8.66	255
Maximum	3.81	3.11	5.72	8.79	322

During the year, butterfat levels dropped from 3.80% in January to 3.60% in July, then rose to 3.81% by November. Protein and SNF showed similar seasonal patterns during the year by bottoming out in the summer and peaking by year-end. The range of variation for butterfat, protein and SNF was 0.21, 0.16 and 0.13 percentage points, respectively. Other solids demonstrated the narrowest range of variation with no apparent seasonal pattern. Other solids levels ranged from a high of 5.72% in June to a low of 5.68% in November and December. The seasonal high SCC of 322,000 was reached in July before dropping to 255,000 in November and December, a change of 67,000 during the year.

Additional analysis was conducted to determine if the difference between the component tests for the months was significantly different. The analysis showed that as a group the means of the monthly component tests were not equal for each component. The same results were found when individual months were compared.

For the year, the simple average butterfat and protein levels were higher than the weighted average for each respective component. The simple averages being higher 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 simple averages 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 2004, the simple average SCC (337,000) was higher than the weighted average (289,000) indicating that larger producers tended to have, on average, lower SCC than their smaller counterparts. Moreover, the median SCC level (260,000) was also lower than the simple average SCC, indicating that the distribution of SCC levels for the market was skewed toward higher SCC levels (see Appendix Figure A-5).[5]

[5] 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 1.534. 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 2

Component Levels and Somatic Cell Count of Milk: Weighted Average, Simple Average, Weighted Standard Deviation, Weighted Median, Minimum and Maximum

2004

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.72	3.81	0.24	3.71	1.27	6.80
Protein	3.03	3.04	0.14	3.02	1.37	4.65
Other Solids	5.71	5.66	0.11	5.72	1.87	6.94
SNF	8.74	8.70	0.18	8.74	4.09	10.18
SCC (1,000's)	289	337	140	260	0	3,995

The range of component levels observed in the data was fairly wide. Individual monthly average butterfat levels in the data were as low as 1.27% and as high as 6.80%; protein levels ranged from 1.37% to 4.65%; other solids levels ranged from 1.87% to 6.94%; SNF levels ranged from 4.09% to 10.18%; and SCC ranged from 0 to 3,995,000.

However, during the year, the component test levels and SCC levels in most producer milk were within one standard deviation of the mean.[6] The ranges of component levels within one standard deviation of the mean were: 3.48% to 3.96% for butterfat; 2.89% to 3.17% for protein; 5.60% to 5.82% for other solids; 8.56% to 8.92% for SNF; and 149,000 to 429,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2004 data were within these ranges[7] (see also Appendix Table A-1 and Appendix Figures A-1 through A-5).

The differences in the weighted and simple averages and the medians of the component tests warrant a closer look at the relationship between farm size, based on monthly average

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

7 The percentage of observations within one standard deviation of the mean in the 2004 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.

milk marketed, and milk component levels. Producers with marketings for each month of 2004 were divided into 10 percentiles, 10 groups with the same number of producers, based on average monthly production. The monthly average production and component tests are shown in Table 3. The range of average monthly production and total production by group are also shown in Table 3.

Table 3

Weighted Average Component Tests by Monthly Average Producer Milk Production 2004

Percentile	Monthly Average Pounds	Butterfat Test	Protein Test	Other Solids Test	Solids Not Fat Test	Somatic Cell Count
		- % -	- % -	- % -	- % -	- 1,000 -
1	19,318	3.92	3.09	5.56	8.65	407
2	36,672	3.86	3.06	5.61	8.66	386
3	49,071	3.84	3.05	5.63	8.68	368
4	60,790	3.82	3.04	5.65	8.69	356
5	73,125	3.81	3.03	5.67	8.70	338
6	87,163	3.80	3.03	5.68	8.71	330
7	105,209	3.78	3.02	5.69	8.71	319
8	132,043	3.77	3.02	5.70	8.72	307
9	186,330	3.76	3.02	5.71	8.73	289
10	735,378	3.65	3.03	5.74	8.77	253
Average	148,520	3.72	3.03	5.71	8.74	289

Monthly Average Producer Milk by Producer Size 2004

Percentile	Number of Producers	Monthly Average Pounds	Minimum Monthly Pounds	Maximum Monthly Pounds	Total Pounds	Percent of Total Pounds	Cumulative Percent of Total
1	23,684	19,318	100	29,636	457,519,292	1.3	
2	23,684	36,672	29,637	43,139	868,543,267	2.5	3.8
3	23,684	49,071	43,140	54,928	1,162,200,789	3.3	7.1
4	23,684	60,790	54,928	66,744	1,439,760,951	4.1	11.2
5	23,684	73,125	66,745	79,698	1,731,896,104	4.9	16.1
6	23,684	87,163	79,699	95,187	2,064,372,858	5.9	22.0
7	23,684	105,209	95,187	116,578	2,491,770,848	7.1	29.0
8	23,684	132,043	116,578	151,345	3,127,309,817	8.9	37.9
9	23,684	186,330	151,347	242,703	4,413,050,678	12.5	50.5
10	23,688	735,378	242,705	24,126,728	17,419,645,303	49.5	100.0
Total or Average	236,844	148,520			33,116,473,573		

A more detailed look at the relationship between producer size and component levels shows that larger producers tend to have lower butterfat tests and SCC than do smaller producers. Producers averaging 19,318 pounds per month had an average butterfat test of 3.92% while producers averaging 735,378 pounds averaged a 3.65% butterfat test. The butterfat test declined steadily from a weighted average of 3.92% for the smallest group to a weighted average of 3.77% and 3.76% for groups 8 and 9, while the group 10 producers, those averaging 735,378 pounds per month, had a weighted average butterfat test of 3.65%. The SCC declined steadily from an average of 407,000 for producers averaging 19,318 pounds per month to an average of 253,000 for producers averaging 735,378 pounds per month, a difference in the SCC of 154,000.

Protein tests also declined from the smaller producers to the larger producers but to a smaller extent than for butterfat, falling from 3.09% for producer's averaging 19,318 pounds per month to 3.02% percent for producers averaging 186,330 pounds of milk marketed per month and 3.03% for producers averaging 735,378 pounds of milk marketed per month. It is interesting to note that the protein test dropped off fairly rapidly and then rose slightly for the largest of the size groups.

Other solids and solids-not-fat tests steadily increased as average monthly production increased. Other solids tests increased from 5.56% to 5.74%, while solids-not-fat tests increased steadily from 8.65% to 8.77% as monthly average production increased from 19,318 pounds to 735,378 pounds.

The data from this group of producers also offers some interesting insight into the structure of the market. For instance, the smallest ten percent of producers supply less than two percent of the milk while the largest ten percent of producers supply almost 50 percent of the milk in the market. More than 80 percent of the producers have a monthly production below the monthly average market production of 148,520 pounds.

Variations in Milk Component Levels and Somatic Cell Counts Within the Marketing Area

Milk component levels and SCC were examined for the seven states that have counties residing within the Upper Midwest Marketing Area (see Table 4). Idaho is also reported separately due to the relatively large percentage of the milk on the market from Idaho in 2004. Differences in average component levels and SCC between the states were observed. One-way analysis of variance was used to determine that the weighted average means of the states were not equal. In addition, several post hoc paired tests were conducted to determine if any of the individual states weighted average means were equal.

These tests indicated that even though the observed dfferences between some of the states were relatively small, the differences between the weighted average means were significant.

Of the states that are wholly or partially located in the Upper Midwest Marketing area, South Dakota had the highest weighted average butterfat test, while Iowa, Idaho, and South Dakota tied for the highest weighted average protein test. Idaho had the highest weighted average other solids test and weighted average SNF test. Of the states that are included in the Upper Midwest Marketing area, Wisconsin had the lowest weighted average SCC and South Dakota had the highest. The aggregated value for the Other states had the lowest SCC overall. Detailed state information by month for 2004 is presented in Table A-2 (see Appendix).

Table 4

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

2004

State	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
Idaho	3.58	3.08	5.73	8.81	236
Illinois	3.74	3.04	5.70	8.73	308
Iowa	3.73	3.08	5.72	8.80	325
Michigan U.P.	3.63	3.03	5.71	8.74	316
Minnesota	3.74	3.04	5.69	8.73	326
North Dakota	3.72	3.06	5.72	8.78	295
South Dakota	3.75	3.08	5.71	8.79	339
Wisconsin	3.74	3.01	5.71	8.72	281
All Other States [8]	3.59	3.02	5.72	8.73	223
Market	3.72	3.03	5.71	8.74	289
Minimum	3.58	3.01	5.69	8.72	223
Maximum	3.75	3.08	5.73	8.81	339

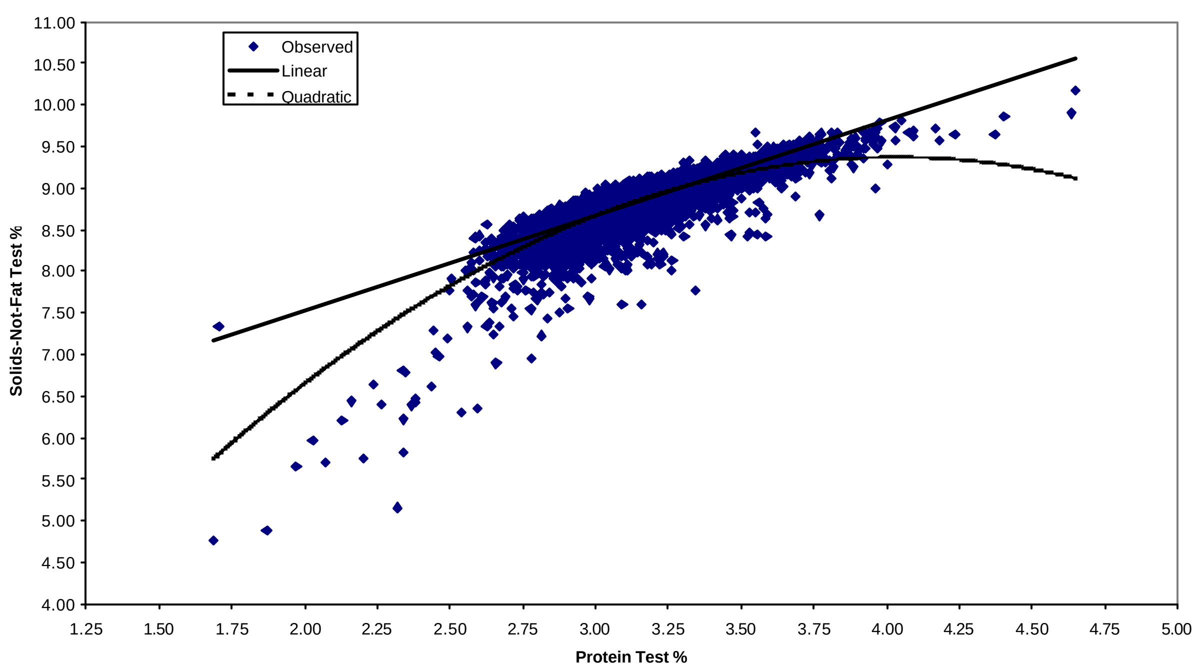
[8] Includes milk from Colorado, Georgia, Indiana, Kansas, Missouri, Montana, Nebraska, Ohio, Oregon, Utah, and Wyoming.

IV. STATISTICAL RELATIONSHIPS AMONG MILK COMPONENTS

Past Upper Midwest staff papers dealing with milk component levels and the relationships between components in the milk discussed the relationships between milk components based on regression analysis using the formula for a straight line. However, if we look at a scatter plot of solids-not-fat and protein, Figure 1, one can see that a straight line has a tendency to miss the points at both the high end of the solids-not-fat and protein tests and the low end. This graph suggests that a relationship other than a linear one may better capture the relationship between solids-not-fat and protein. A quadratic model was found to result in a slightly better explanation of the relationship between butterfat and protein and solids-not-fat and protein than the linear model. For consistency with past studies, a discussion of the linear models and coefficients are included in this study. In addition, a discussion of the quadratic model and the resulting regression coefficients are included.

Figure 1

Scatter Plot of Solids-Not-Fat and Protein Tests -- January 2004



Regression analysis was used to estimate the linear relationship between components. Results from the 2004 data were compared with results from previous Upper Midwest Order studies (1993-2003), 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) + . . . + 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).

The general form of a quadratic equation and the one used in this study is:

Component A = c + b1 (Component B) + b2 (Component B-squared) + e

Where, Component A is the dependent variable, c is a constant, b1 and b2 are coefficients, Component B is an independent variable, and e is an error term. Since it has been previously determined that there are significant differences between monthly average component tests, individual equations were developed for each month (see Appendix Table A-3).

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 variations 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 5, 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 sixteen 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 2004 data was within that range at 0.3902. No attempt was made to identify possible causes for the change in the butterfat coefficient.

Monthly dummy variables were added to the above equation to look at the impact of seasonality on the relationship between butterfat and solids-not-fat. Dummy variables for February through December were added. Table A-3 (see Appendix) contains the coefficients and related information for the constant, butterfat and months. Including the monthly variables slightly improved the R-squared value when compared to not including the monthly variables, and all of the months except June were significant, indicating that season of the year has an impact on the relationship between solids-not-fat and butterfat. As pointed out earlier in this paper, the component data is based on milk of producers located predominately in the Upper Midwest. Component levels of producers in other areas of the United States may show seasonal trends but the timing of the trends probably will not be the same as those shown in the Upper Midwest.

Applying a quadratic formula to the relationship between solids-not-fat and butterfat resulted in no applicable difference from the linear model.

Table 5

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

Study (Region and Year)	Equation
Upper Midwest (2006)	SNF = 7.21824% + 0.39023 (BF)
Upper Midwest (2006 Staff Paper 06-01)	SNF = 7.13098% + 0.41596 (BF)
Upper Midwest (2003)	SNF = 7.15780% + 0.40439 (BF)
Upper Midwest (2002)	SNF = 7.06534% + 0.42925 (BF)
Upper Midwest (2001)	SNF = 7.21994% + 0.38823 (BF)
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 6). The 2004 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). The regression containing the monthly variables performed as expected, all parameters were statistically significant and of the expected sign. The R-squared statistic for the formula containing monthly variables was slightly greater than for the formula without the monthly variables. The monthly coefficients appeared to have a seasonal pattern as they increased from February to June and then decreased to the end of the year.

Figure 1 is a scatter plot of monthly producer solids-not-fat and protein tests for January 2004. The straight line is the result of the linear model for January while the curved line is the result of the quadratic model for January. This graph is representative of the data for each month and the annual data. The equation for 2004, for the linear model is:

$$\textit{Solids-not-fat Test} = 5.41126 + 1.08236 * \textit{Protein Test},$$

while the equation for the quadratic model is:

$$\textit{Solids-not-fat Test} = 0.26414 + (4.39820 * \textit{Protein Test}) + (-0.53219 * (\textit{Protein Test})^2).$$

The R-squared for the linear model is 0.649, while the R-squared for the quadratic model is 0.672. The quadratic model has a slightly better fit than the linear model and is concave downward.

Both the linear model and the quadratic model yielded similar results when the protein tests were within the first standard deviation, while the quadratic model appears to fit the data better than the linear model at the higher and lower protein tests. The reason that the relationship between solids-not-fat and protein is not constant across the entire range of tests may be due to variables that were not measured in this study, such as breed of the individual farm herds, ration, and feeding practices.

Table 6

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

Study (Region and Year)	**Equation**
Upper Midwest (2006)	SNF = 5.41126% + 1.08236 (PRO)
Upper Midwest (2006 Staff Paper 06-01)	SNF = 5.30149% + 1.12321 (PRO)
Upper Midwest (2003)	SNF = 5.39150% + 1.08985 (PRO)
Upper Midwest (2002)	SNF = 5.38415% + 1.09176 (PRO)
Upper Midwest (2001)	SNF = 5.43058% + 1.07894 (PRO)
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 2004 data and those of Halverson/Kyburz (see Table 7). The primary observation from the equation derived for the 2004 data was that the constant of 1.59839 and coefficient of 0.37888 for the independent variable were approximately the same as for the 2003 data.

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 variables, except February, were statistically significant and of the expected sign. The R-squared statistic was again slightly higher for the formula using the monthly variables than for the formula without the monthly variables.

Table 7

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

Study (Region and Year)	Equation
Upper Midwest (2006)	PRO = 1.59839% + 0.37888 (BF)
Upper Midwest (2006 Staff Paper 06-01)	PRO = 1.56388% + 0.38754 (BF)
Upper Midwest (2003)	PRO = 1.55781% + 0.38770 (BF)
Upper Midwest (2002)	PRO = 1.47804% + 0.40962 (BF)
Upper Midwest (2001)	PRO = 1.55107% + 0.38831 (BF)
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)

Figure 2 is a scatter plot of monthly average producer butterfat tests and protein tests for January 2004 data. The straight line is the result of the linear model for January while the curved line is the result of the quadratic model for January. The equation for January, for the linear model is:

*Protein Test = 1.59839 + 0.37888 * Butterfat Test,*

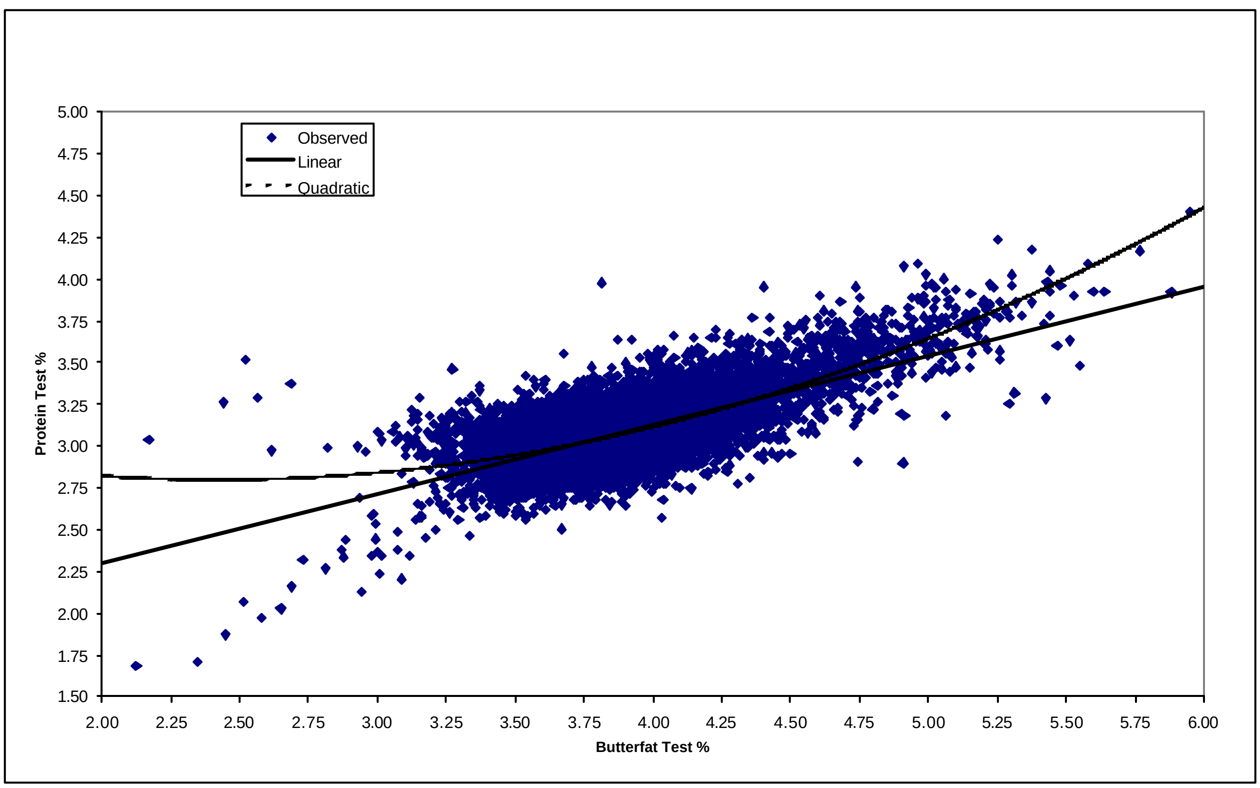
while the equation for the quadratic model is:

$$\text{Protein Test} = 3.7247 + (-0.7256 * \text{Butterfat Test}) + (0.1427 * (\text{Butterfat Test})^2).$$

As one can see in Figure 2, the linear model has a tendency to understate the estimate of the protein test at the higher butterfat tests, while the quadratic model's estimate of the protein test seems to follow the actual protein tests more closely at the higher range of butterfat tests. In the range of butterfat tests included in one standard deviation of the mean, both the linear and quadratic models appear to give similar results. At the lower range of the butterfat tests, the protein tests seem to split, with some increasing with decreasing butterfat tests, and some decreasing with decreasing butterfat tests. The linear model seems to fall between the split in the tests while the quadratic model estimates increasing protein tests with decreasing butterfat tests. The quadratic model, for the 2004 dataset has a significantly higher adjusted R-squared of 0.449, versus 0.426 for the linear model, suggesting a better fit. The remaining months of 2004 had a similar difference in the R-squared value between the linear model and the quadratic model.

Figure 2

Scatter Plot of Protein and Butterfat Tests -- January 2004



Even though the quadratic model does show a slightly better fit than the linear model, the point to note is the relationship between butterfat and protein is not constant across the range of average butterfat and protein tests found in this study. It is also important to note that the data included in this study are average monthly tests from numerous herds, and that the butterfat to protein ratio may be affected by various variables, which are not included in this study. Some of these variables may include breed; traditionally the colored breeds have had higher butterfat tests and may have a higher proportion of protein that would show up in the larger number of observations at the higher butterfat tests. Ration and feeding practices may also have an impact on butterfat to protein ratios.

Other Solids Levels

Beginning in 2000, as part of Federal order reform, the other solids price on the Upper Midwest order was calculated from the survey price[9] for dry whey rather than being the residual 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.

Other solids, for purposes of Federal milk order pricing, are defined as solids-not-fat minus protein. Therefore, other solids consist primarily of lactose and ash. Ash traditionally has been considered a constant in solids-not-fat, while lactose does vary somewhat in the solids-not-fat.

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 0.654 suggests that a moderately strong linear relationship exists while protein and SNF appears to have a strong relationship with a coefficient of 0.807. These results, however, are not surprising due to the fact that SNF is the sum of the protein and other solids components.

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9 Component prices are calculated from the weighted average values of survey information on cheddar cheese, butter, nonfat dry milk and dry whey sales gathered by the National Agricultural Statistics Service, USDA.

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.

Hypothesis Tests Among Milk Components

As mentioned above, various regressions are estimated between component tests to determine what statistical relationships exist. These relationships can be further inspected to determine if the underlying structure of the regression equation is statistically significant. The regression equations include simple linear equations, quadratic equations, (already presented on page 10) and both fixed effects and random effects models. Briefly the equations are as follows:

Simple Linear $$Y ? ? ? ?X ? ?$$

Quadratic $$Y ? ? ? ?_1 X ? ?_2 X^2 ? ?$$

Fixed Effects $$Y ? ?_1 X ? ?_2 D_{jan} \square ? ?_{13} D_{dec} ? ?$$

which has an equivalent representation estimated in earlier studies and included in Table A-3 as:

$$Y ? ?_c ? ?_1 D_{feb} ? \square ?_{11} D_{dec} ? ?X ? ?$$

Where the equivalency comes in as:

$$?_1 ? ?_c ? ?_2$$

So for the month of February and the model where the SNF test is the dependent variable with the protein test as the independent variable (using results from Table 8 on the following page and Table A-3 in the appendix):

$$?_{feb} ? 5.2386 ? (?0.0151) ? 5.2235$$

The Fixed Effects model has the assumption that the underlying differences in the data between two units can be attributed to a difference in the constant term thus preserving and assuming the relationship between the independent and dependent variable represented by the beta coefficient is constant.

Table 8

Fixed Effects Model for 2004

$$SNFtest\ ?\ ?_1\text{Protein test}\ ?\ ?_{\text{jan}} \square\ ?\ ?_{dec}\ ?\ ?$$

Variable	**Beta**	**Standard Error**	**t-stat**
Protein Test	**1.142111**	**0.001708**	**668.7699**
January	5.238592	0.005337	981.6497
February	5.223480	0.005303	985.0763
March	5.246225	0.005253	998.6984
April	5.253970	0.005214	1007.724
May	5.265013	0.005200	1012.416
June	5.270513	0.005155	1022.447
July	5.249204	0.005112	1026.792
August	5.243878	0.005191	1010.171
September	5.217067	0.005254	992.8787
October	5.187635	0.005418	957.4894
November	5.170333	0.005434	951.5004
December	5.187337	0.005400	960.5614

Dependent Variable: Solids-Not-Fat Test
Linear Regression through the Origin

$$\text{Protein test}\ ?\ ?_1 Butterfat\,test\ ?\ ?_{jan} \square\ ?_{dec}\ ?\ ?$$

Variable	**Beta**	**Standard Error**	**t-stat**
Butterfat Test	**0.376656**	**0.000981**	**384.1212**
January	1.616520	0.003903	414.1677
February	1.596232	0.003903	408.9496
March	1.579390	0.003871	407.9661
April	1.568699	0.003839	408.6246
May	1.578354	0.003795	415.9574
June	1.577203	0.003729	423.0042
July	1.569047	0.003685	425.7848
August	1.602375	0.003719	430.8155
September	1.624075	0.003760	431.9514
October	1.667295	0.003897	427.8828
November	1.658577	0.003943	420.6706
December	1.639788	0.003940	416.2204

Dependent Variable: Protein Test
Linear Regression through the Origin

Table 8 (continued)

Fixed Effects Model for 2004

$$SNF\ test\ ?\ ?_1 Butterfat\ test\ ?\ ?_{jan} \ldots\ ?\ ?_{dec}\ ?\ ?$$

Variable	Beta	Standard Error	t-stat
Butterfat Test	**0.410248**	**0.001550**	**264.657**
January	7.162215	0.006170	1160.797
February	7.123925	0.006170	1154.534
March	7.126783	0.006120	1164.506
April	7.121629	0.006069	1173.486
May	7.142772	0.005998	1190.762
June	7.145576	0.005894	1212.294
July	7.114038	0.005825	1221.192
August	7.147489	0.005880	1215.610
September	7.146296	0.005944	1202.329
October	7.169079	0.006160	1163.829
November	7.142775	0.006233	1146.007
December	7.138252	0.006228	1146.149

Dependent Variable: Solids-Not-Fat Test
Linear Regression through the Origin

The F-Test

The F-Test allows us to test the hypothesis that the inclusion of monthly variables are not significant or that their contribution is not significantly different from zero. This test differs from the Overall F (or Global F) test which tests the hypothesis that all coefficients in a model are zero. The following F-test is limited to the monthly dummy variables. To carry out the test the R_u^2 values for the unrestricted (unrestricted in the sense the coefficients for the monthly dummy variables aren't assigned a zero value) models are compared to the R_p^2 pooled or restricted models.

$$F(n\ ?\ 1, nT\ ?\ n\ ?\ K)\ ?\ \frac{(R_u^2\ ?\ R_p^2) / (n\ ?\ 1)}{(1\ ?\ R_u^2) / (nT\ ?\ n\ ?\ K)}$$

Table 9

F-Test Results for Monthly Data

Model	**n-1**	**nT-n-K**	**F-value**	**Critical Value**
Solids-Not-Fat and Butterfat	11	236831	32733818	2.18
Protein and Butterfat	11	236831	7669125	2.18
Solids-Not-Fat and Protein	11	236831	34222381	2.18

The 1% significance level at these degrees of freedom is 1.00 so the hypothesis that all the monthly effects are the same is rejected.

Random Effects

The Random Effects model assumes the constant is unchanging between units but that the variation is due to differences in the underlying relationship between the independent and dependent variables as represented by the beta coefficient. This model also then can be interpreted as a missing or omitted variable construction that can be used for hypothesis testing.

$$Y \; ? \; ?_{c} \; ? \; ?_{1} X_{jan} \; ? \ldots \; ? \; ?_{12} X_{dec} \; ? \; ?$$

The hypothesis tests involving these models include simple t-statistics, F-tests, and Lagrange Multiplier statistics.

Table 10

Random Effects Model for 2004

$$\text{Protein test} \; ? \; ? \; ? \; ?_{\text{jan}} \, Butterfat\,test \ldots \; ?_{dec} \, Butterfat\,test \; ? \; ?$$

	Beta	Standard Error	t-stat
(Constant)	**1.610744**	**0.003748**	**430**
January	0.378318	0.000986	384
February	0.373082	0.000987	378
March	0.368569	0.000995	370
April	0.365522	0.001004	364
May	0.367856	0.001017	362
June	0.367419	0.001036	355
July	0.365235	0.001050	348
August	0.374337	0.001039	360
September	0.380168	0.001028	370
October	0.391232	0.000989	396
November	0.388944	0.000977	398
December	0.384181	0.000977	393

Dependent Variable: Protein

Table 10 (continued)
Random Effects Model for 2004

$$SNFtest = \alpha + \beta_{jan} Butterfat\ test + \dots + \beta_{dec} Butterfat\ test + \varepsilon$$

	Beta	Standard Error	t-stat
(Constant)	**7.139117**	**0.005930**	**1204**
January	0.416343	0.001560	267
February	0.406510	0.001561	260
March	0.407116	0.001574	259
April	0.405602	0.001589	255
May	0.411065	0.001609	256
June	0.411988	0.001639	251
July	0.403646	0.001660	243
August	0.412652	0.001644	251
September	0.412152	0.001626	254
October	0.417787	0.001565	267
November	0.411001	0.001545	266
December	0.409864	0.001546	265

Dependent Variable: Solids-Not-Fat Test

The Lagrange Multiplier Test

$$LM = \frac{nT}{2(T-1)}\left[\frac{e'DD'e}{e'e} - 1\right]^2$$

The Lagrange Multiplier test is distributed as a chi-squared with one degree of freedom since we're testing the constraint that the off-diagonal components are zero resulting in a zero variance for the supposed missing variable. The critical values for this distribution are then 2.71 and 6.63 at the 90% and 99% confidence levels.

Table 11
Lagrange Multiplier Tests for the Random Effects Model

Model	Months	States
Butterfat and Protein	104	8,159
Butterfat and Solids-Not-Fat	15,559	2,334
Somatic Cell Count and Butterfat	19,811	139,980

The Lagrange Multiplier values above reject the null hypothesis at the 99% level for monthly data indicating the random effects model is appropriate. This evidence can further imply that there is some model misspecification in the form of omitted variables. The value for the state data is not able to reject the null hypothesis; this result is probably due to the larger within unit variation in the state data.

The Correlation Decomposition

By examining the data in units and comparing the behavior of those units to the group as a whole and to each other we can get some idea of which model is most appropriate. Our units will be comprised of individual producer data points grouped according to month and also for state. Once the models are estimated a weighted measure of variation can be computed. This number shows the importance of the between units variation to the overall variation relative to the variation within units. Again this can determine in our case whether there is more variation within months versus between months and whether there's more variation between states versus variation within a state. Computing this number begins with the coefficients of correlation for the dataset as a whole, b^t, the correlation within units, b^w, and the correlation between units, b^b. These correlation coefficients are defined as follows:

$$b^t = \left(S^t_{xx}\right)^{-1}\left(S^t_{xy}\right), \quad b^w = \left(S^w_{xx}\right)^{-1}\left(S^w_{xy}\right), \quad b^b = \left(S^b_{xx}\right)^{-1}\left(S^b_{xy}\right).$$

Where S^t_{xx} is the sum of the squared x's for the dataset and S^w_{xx} is the sum of squared x's for the within units data etc.

We then compute m as follows:

$$m = \frac{b^t - b^b}{b^w - b^b}$$

where m decomposes the total correlation into the portion attributable to between the units, b^b and that amount determined by within unit correlation, b^w.

$$b^t = mb^w + (1 - m)b^b.$$

For the monthly and state data the results are:

Table 12

Correlation Decomposition May 2004

	State			Month		
Coefficient	**Butterfat and Protein**	**Butterfat and Solids-Not-Fat**	**Somatic Cell Count and Butterfat**	**Butterfat and Protein**	**Butterfat and Solids-Not-Fat**	**Somatic Cell Count and Butterfat**
m	1.09020	1.08210	1.23610	0.88782	0.88726	0.98122
b^b	0.48159	0.50047	0.00001	0.59159	0.44785	-0.00348
b^w	0.40745	0.42101	-0.00001	0.37666	0.41025	0.00004
b^t	0.40077	0.41449	-0.00002	0.40077	0.41449	-0.00002

Applying the estimated values from column one of Table 12 to the above equation:

$$b^t \ ? \ 1.0902 * .40745 \ ? \ (1 \ ? \ 1.0902) * .48159 \ ? \ .40077$$

you can see from the values of m, most of the variation in the data is within the month and within the state (taking the full weight of 1.0902 versus the weight of .0902 for the between month correlation) data. The variation between months and between states is much less.

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 2004. 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 2004, the cumulative value of butterfat, protein, other solids and an adjustment for SCC averaged $16.03 per cwt. for the market. The value of each component comprised by the $16.03 per cwt. price was $7.63 for butterfat, $7.91 for protein, and $0.43 for other solids. The SCC adjustment for the year amounted to about $0.05 per cwt.

Categorized by size range of delivery, average values of producer milk ranged from a low of $15.88 per cwt. for monthly producer milk deliveries greater than 400,000 pounds to a high of $16.28 per cwt. for monthly producer milk deliveries of less than 20,000 pounds (see Appendix Table A-5). In general, the average value of producer milk declined as monthly deliveries increased. These results correspond well to comparisons between simple and weighted average component levels in Part III of this paper.

VI. 2000 - 2004 WEIGHTED AVERAGE COMPONENT TESTS

Weighted average component data for the past five years, 2000, 2001, 2002, 2003 and 2004, are shown in Table 8. Over these five years the yearly average tests have changed very little. Yearly average butterfat tests were 3.73 percent, 3.70 percent, 3.72 percent 3.69 percent and 3.72 percent for 2000, 2001, 2002, 2003 and 2004 respectively. Yearly average protein and other solids tests varied even less than the butterfat test with only a .03 percent difference between the five years. Yearly weighted average somatic cell counts also did not change much over the three-year period, increasing slightly from 2000 to 2001 and then declining from 336,000 in 2001 to 289,000 in 2004.

Graphs (see Appendix Figures A-6 through A-10) show the monthly weighted average component tests for 2000, 2001, 2002, 2003 and 2004. As one can see in the graphs, the butterfat and protein tests varied very little from year to year and showed a consistent yearly pattern. Other solids weighted average monthly tests showed more inconsistency from year to year than either the butterfat or protein monthly weighted average tests. Since nonfat solids consist primarily of protein and other solids, the monthly variations from year to year are predominantly a result of the fluctuations in the protein and other solids tests.

Somatic cell counts also showed a consistent seasonal pattern, increasing in the summer and declining through the fall and winter.

Year to year changes in components and SCC counts may be attributed to several factors including changes in feeding practices, breeding, composition of the dairy herd, weather and in the case of SCC herd health. Breeding and composition of the dairy herd take relatively longer periods of time for the changes in component levels to show up. The data for the years 2000, 2001, 2002, 2003 and 2004 would indicate that these two factors have not had an impact on the weighted average component tests of the market. Probably the largest factor influencing year-to-year fluctuations in component tests and SCC is the weather.

Table 13

Weighted Average Levels of Selected Components and Somatic Cell Count in Milk Year to Year

2000

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.82	3.05	5.67	8.71	308
February	3.79	3.02	5.68	8.70	317
March	3.76	3.00	5.72	8.71	328
April	3.76	3.00	5.72	8.71	322
May	3.67	2.95	5.74	8.69	328
June	3.64	2.95	5.74	8.69	351
July	3.58	2.91	5.72	8.63	374
August	3.59	2.92	5.69	8.62	381
September	3.67	3.00	5.69	8.69	358
October	3.77	3.06	5.69	8.75	317
November	3.82	3.07	5.70	8.77	307
December	3.85	3.08	5.68	8.76	308
Annual Average	3.73	3.00	5.70	8.70	333

2001

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.80	3.05	5.69	8.73	328
February	3.78	3.04	5.70	8.74	321
March	3.76	3.06	5.67	8.73	325
April	3.73	2.99	5.72	8.71	323
May	3.64	2.96	5.73	8.70	326
June	3.61	2.94	5.70	8.65	341
July	3.55	2.90	5.71	8.61	371
August	3.55	2.92	5.69	8.62	390
September	3.66	3.03	5.70	8.73	360
October	3.77	3.11	5.69	8.80	318
November	3.80	3.10	5.69	8.78	306
December	3.81	3.08	5.69	8.77	319
Annual Average	3.70	3.01	5.70	8.71	336

Table 13 (continued)

Weighted Average Levels of Selected Components and Somatic Cell Count in Milk Year to Year

2002

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.79	3.05	5.70	8.75	317
February	3.77	3.03	5.70	8.74	318
March	3.77	3.04	5.71	8.75	320
April	3.73	3.00	5.74	8.74	322
May	3.70	2.98	5.74	8.72	310
June	3.63	2.94	5.74	8.68	325
July	3.55	2.88	5.71	8.60	379
August	3.57	2.94	5.70	8.65	386
September	3.65	3.00	5.70	8.70	346
October	3.79	3.09	5.71	8.80	307
November	3.83	3.10	5.69	8.79	300
December	3.80	3.07	5.69	8.76	289
Annual Average	3.72	3.01	5.71	8.72	326

2003

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.77	3.03	5.72	8.75	301
February	3.75	3.04	5.71	8.75	314
March	3.74	3.02	5.73	8.75	316
April	3.70	2.99	5.75	8.74	308
May	3.65	2.96	5.75	8.71	315
June	3.59	2.95	5.75	8.69	322
July	3.54	2.92	5.71	8.63	345
August	3.54	2.92	5.70	8.62	348
September	3.64	3.01	5.70	8.72	330
October	3.77	3.09	5.69	8.78	290
November	3.84	3.11	5.71	8.83	274
December	3.82	3.09	5.71	8.80	277
Annual Average	3.69	3.01	5.72	8.73	312

Table 13 (continued)

Weighted Average Levels of Selected Components and Somatic Cell Count in Milk Year to Year

2004

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.80	3.07	5.72	8.79	280
February	3.80	3.06	5.70	8.75	291
March	3.75	3.02	5.71	8.73	300
April	3.71	3.01	5.71	8.72	295
May	3.68	2.99	5.72	8.71	290
June	3.63	2.97	5.72	8.69	308
July	3.60	2.95	5.71	8.66	322
August	3.63	2.99	5.72	8.71	317
September	3.67	3.02	5.71	8.74	291
October	3.77	3.10	5.69	8.79	263
November	3.81	3.11	5.68	8.79	255
December	3.80	3.10	5.68	8.78	255
Annual Average	3.72	3.03	5.71	8.74	289

VII. SUMMARY

This staff paper analyzes milk components and SCC in producer milk associated with the Upper Midwest Order during 2004. The data include component levels for butterfat, protein, other solids, 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 2004 were: 3.72% butterfat, 3.03% protein, 5.71% other solids, 8.74% SNF and 289,000 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 May and June and lowest in November and December and exhibited less variation during the year relative to the three other components. Weighted average SCC were lowest in November and December and highest in July. Approximately three-quarters of monthly average component levels ranged from: 3.48% to 3.96% for butterfat; 2.89% to 3.17% for protein; 5.60% to 5.82% for other solids; 8.56% to 8.92% for SNF; and 149,000 to 429,000 for SCC.

Smaller producers, based on average monthly milk marketed, had higher butterfat tests, protein tests and SCC than larger producers, while larger producers had higher other solids and solids-not-fat tests than smaller producers.

The smallest ten percent of producers marketed less than two percent of the milk while the largest ten percent of producers marketed almost 50 percent of the milk. The monthly average pounds of milk marketed were 148,520 pounds, however over 80 percent of the producers had average marketings below the market average.

Based on the data for 2004, the following regression equations were derived:

$$SNF = 7.21824\% + 0.39023\ (BF)$$
$$SNF = 5.41126\% + 1.08236\ (PRO)$$
$$PRO = 1.59839\% + 0.37888\ (BF)$$

Under MCP, the annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $16.03 per cwt. for the market. Protein contributed slightly more than half of the total value.

BIBLIOGRAPHY

Bhattacharyya, Gouri H. and Johnson, Richard A. Statistical Concepts and Methods. John Wiley & Sons, New York. 1977.

Freije, Corey. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 2003." Upper Midwest Marketing Area Staff Paper 06-01. April 2006.

Halverson, Victor and Kyburz, H. Paul. "Analysis of Component Levels in Individual Herd Milk at the Farm Level: 1984 and 1985." Upper Midwest Marketing Area Staff Paper 86-01. March 1986.

Jack, E. L., et al. "Relationship of Solids-Not-Fat to Fat in California Milk." California Agricultural Experiment Station Bulletin 726. September 1951.

Jacobson, Moses S. "Butterfat and Total Solids in New England Farmers' Milk as Delivered to Processing Plants." Journal of Dairy Science, 19:171-76. 1936.

Mykrantz, John L. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1992." Upper Midwest Marketing Area Staff Paper 93-01. June 1993.

Mykrantz, John L. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1993." Upper Midwest Marketing Area Staff Paper 94-01. May 1994.

Schaefer, Henry H. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 2001." Upper Midwest Marketing Area Staff Paper 02-02. December 2002.

Schaefer, Henry H. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 2002." Upper Midwest Marketing Area Staff Paper 03-01. December 2003.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1994." Upper Midwest Marketing Area Staff Paper 95-01. August 1995.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1995." Upper Midwest Marketing Area Staff Paper 96-02. September 1996.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1996." Upper Midwest Marketing Area Staff Paper 97-01. September 1997.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1997." Upper Midwest Marketing Area Staff Paper 98-01. July 1998.

BIBLIOGRAPHY - continued

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1998." Upper Midwest Marketing Area Staff Paper 99-01. July 1999.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 1999." Upper Midwest Marketing Area Staff Paper 00-02. September 2000.

Sebastian, Rodney M. "Analysis of Component Levels and Somatic Cell Count in Individual Herd Milk at the Farm Level: 2000." Upper Midwest Marketing Area Staff Paper 01-02. November 2001.

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APPENDIX

TABLES

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Table A-1

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

2004

Butterfat

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	- % -	- % -	- % -	- % -	- % -	- % -	
January	3.80	3.88	0.23	3.79	1.67	6.36	19,942
February	3.80	3.88	0.24	3.78	2.12	6.33	19,817
March	3.75	3.85	0.24	3.74	2.21	6.29	19,951
April	3.71	3.81	0.23	3.70	1.27	5.70	19,835
May	3.68	3.77	0.23	3.67	1.91	5.63	19,843
June	3.63	3.70	0.21	3.62	2.14	5.42	19,797
July	3.60	3.65	0.21	3.59	1.99	5.42	19,765
August	3.63	3.69	0.21	3.63	1.85	5.46	19,710
September	3.67	3.73	0.22	3.66	1.83	5.70	19,610
October	3.77	3.87	0.24	3.76	2.00	6.09	19,575
November	3.81	3.92	0.25	3.79	1.93	6.80	19,525
December	3.80	3.92	0.26	3.79	2.37	6.68	19,474
Total	3.72	3.81	0.24	3.71	1.27	6.80	236,844

Protein

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	- % -	- %	- % -	% -	- % -	- % -	
January	3.07	3.08	0.13	3.06	1.68	4.65	19,942
February	3.06	3.06	0.13	3.05	1.63	4.64	19,817
March	3.02	3.03	0.12	3.02	1.69	4.41	19,951
April	3.01	3.01	0.12	3.00	1.59	4.08	19,835
May	2.99	3.00	0.12	2.98	1.59	4.00	19,843
June	2.97	2.97	0.12	2.96	1.66	4.19	19,797
July	2.95	2.94	0.12	2.94	1.66	3.80	19,765
August	2.99	2.99	0.12	2.98	1.37	4.08	19,710
September	3.02	3.03	0.12	3.01	1.67	4.06	19,610
October	3.10	3.13	0.13	3.09	1.79	4.34	19,575
November	3.11	3.14	0.13	3.10	1.58	4.43	19,525
December	3.10	3.12	0.13	3.09	1.86	4.61	19,474
Total	3.03	3.04	0.14	3.02	1.37	4.65	236,844

Table A-1 (continued)

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

2004

Other Solids

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	- % -	- % -	- % -	- % -	- % -	- % -	
January	5.72	5.68	0.10	5.73	2.84	6.12	19,942
February	5.70	5.66	0.10	5.71	3.05	5.99	19,817
March	5.71	5.68	0.09	5.72	3.02	6.29	19,951
April	5.71	5.68	0.10	5.73	3.07	6.42	19,835
May	5.72	5.69	0.09	5.74	3.41	6.14	19,843
June	5.72	5.69	0.10	5.74	3.29	6.19	19,797
July	5.71	5.67	0.15	5.73	2.82	6.12	19,765
August	5.72	5.67	0.10	5.74	2.72	6.07	19,710
September	5.71	5.65	0.11	5.72	2.76	6.07	19,610
October	5.69	5.63	0.10	5.71	3.85	6.94	19,575
November	5.68	5.62	0.10	5.69	1.87	5.97	19,525
December	5.68	5.63	0.10	5.70	3.16	5.97	19,474
Total	5.71	5.66	0.11	5.72	1.87	6.94	236,844

Solids-Not-Fat

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	- % -	- % -	- % -	- % -	- % -	- % -	
January	8.79	8.75	0.18	8.80	4.76	10.17	19,942
February	8.75	8.72	0.18	8.76	4.68	9.90	19,817
March	8.73	8.71	0.17	8.74	5.03	10.18	19,951
April	8.72	8.69	0.17	8.73	4.66	9.76	19,835
May	8.71	8.69	0.16	8.72	5.00	9.73	19,843
June	8.69	8.66	0.17	8.70	4.94	9.66	19,797
July	8.66	8.61	0.21	8.68	4.48	9.46	19,765
August	8.71	8.66	0.17	8.72	4.09	9.83	19,710
September	8.74	8.68	0.18	8.74	4.64	9.79	19,610
October	8.79	8.76	0.17	8.80	6.58	10.03	19,575
November	8.79	8.75	0.17	8.80	4.93	10.05	19,525
December	8.78	8.75	0.17	8.78	6.53	10.08	19,474
For the Year	8.74	8.70	0.18	8.74	4.09	10.18	236,844

Table A-1 (continued)

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

2004

Somatic Cell Count

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	----------	----------	---------- (1,000)	----------	----------	----------	
January	280	322	137	252	27	1,866	19,942
February	291	330	147	259	21	2,471	19,817
March	300	348	150	270	20	3,995	19,951
April	295	342	142	264	23	2,935	19,835
May	290	335	136	261	11	2,038	19,843
June	308	360	148	280	17	2,777	19,797
July	322	379	149	294	19	2,743	19,765
August	317	371	143	291	0	3,257	19,710
September	291	341	132	265	0	1,604	19,610
October	263	309	122	240	0	1,900	19,575
November	255	303	124	230	0	2,053	19,525
December	255	306	126	229	21	1,885	19,474
For the Year	289	337	140	260	0	3,995	236,844

Table A-2

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2004

Butterfat

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.73	3.86	3.83	3.72	3.81	3.77	3.85	3.81	3.66	3.80
February	3.68	3.85	3.82	3.70	3.81	3.76	3.84	3.80	3.65	3.80
March	3.59	3.81	3.78	3.56	3.76	3.73	3.78	3.77	3.64	3.75
April	3.54	3.75	3.72	3.59	3.72	3.72	3.73	3.74	3.57	3.71
May	3.48	3.66	3.66	3.60	3.70	3.68	3.72	3.71	3.53	3.68
June	3.48	3.61	3.62	3.49	3.66	3.61	3.66	3.65	3.42	3.63
July	3.45	3.58	3.59	3.54	3.64	3.56	3.62	3.61	3.49	3.60
August	3.47	3.63	3.64	3.60	3.67	3.60	3.66	3.65	3.46	3.63
September	3.58	3.68	3.68	3.63	3.71	3.69	3.73	3.67	3.50	3.67
October	3.61	3.81	3.81	3.66	3.81	3.81	3.82	3.79	3.74	3.78
November	3.70	3.84	3.82	3.71	3.83	3.86	3.83	3.82	3.76	3.81
December	3.68	3.82	3.81	3.74	3.81	3.86	3.83	3.82	3.76	3.80
Total	3.58	3.74	3.73	3.63	3.74	3.72	3.75	3.74	3.59	3.72

Protein

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.12	3.08	3.14	3.07	3.08	3.11	3.14	3.06	3.07	3.07
February	3.11	3.06	3.13	3.06	3.08	3.10	3.14	3.03	3.07	3.06
March	3.07	3.02	3.08	3.01	3.04	3.07	3.09	3.01	3.02	3.02
April	3.05	3.00	3.05	2.97	3.02	3.03	3.07	2.99	2.99	3.01
May	3.03	2.99	3.03	2.95	3.01	3.00	3.05	2.97	2.97	2.99
June	3.02	2.94	2.99	2.96	3.00	3.00	3.01	2.94	2.97	2.97
July	2.98	2.94	2.98	2.97	2.97	2.97	2.99	2.93	2.95	2.95
August	3.01	2.98	3.03	3.04	3.01	3.02	3.02	2.97	2.97	2.99
September	3.11	3.04	3.07	3.05	3.01	3.04	3.04	3.00	3.03	3.02
October	3.14	3.13	3.16	3.10	3.09	3.13	3.12	3.09	3.09	3.10
November	3.18	3.14	3.17	3.08	3.12	3.14	3.15	3.09	3.08	3.11
December	3.14	3.11	3.16	3.09	3.10	3.14	3.13	3.08	3.05	3.10
Total	3.08	3.04	3.08	3.03	3.04	3.06	3.08	3.01	3.02	3.03

Table A-2 (Continued)
WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2004
Other Solids

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	5.70	5.71	5.75	5.74	5.72	5.77	5.73	5.71	5.77	5.72
February	5.68	5.70	5.72	5.70	5.66	5.70	5.67	5.71	5.78	5.70
March	5.68	5.70	5.73	5.72	5.69	5.72	5.69	5.72	5.70	5.71
April	5.72	5.71	5.74	5.72	5.69	5.74	5.70	5.72	5.39	5.71
May	5.74	5.71	5.72	5.72	5.71	5.74	5.73	5.72	5.73	5.72
June	5.74	5.71	5.70	5.71	5.71	5.74	5.73	5.74	5.77	5.73
July	5.70	5.69	5.71	5.71	5.70	5.74	5.72	5.72	5.69	5.71
August	5.78	5.70	5.71	5.74	5.71	5.74	5.74	5.72	5.78	5.72
September	5.81	5.69	5.70	5.69	5.71	5.74	5.74	5.69	5.80	5.71
October	5.76	5.68	5.70	5.69	5.66	5.69	5.69	5.69	5.76	5.69
November	5.73	5.69	5.71	5.68	5.63	5.66	5.67	5.68	5.74	5.67
December	5.70	5.69	5.71	5.69	5.66	5.68	5.69	5.68	5.74	5.68
Total	5.73	5.70	5.72	5.71	5.69	5.72	5.71	5.71	5.72	5.71

Solids-Not-Fat

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	8.83	8.79	8.89	8.80	8.80	8.88	8.87	8.77	8.83	8.79
February	8.79	8.76	8.86	8.76	8.74	8.80	8.81	8.74	8.85	8.75
March	8.75	8.72	8.81	8.73	8.73	8.79	8.78	8.73	8.73	8.73
April	8.77	8.71	8.79	8.70	8.71	8.77	8.78	8.71	8.38	8.72
May	8.77	8.70	8.75	8.67	8.72	8.74	8.77	8.69	8.70	8.71
June	8.75	8.65	8.70	8.67	8.70	8.74	8.74	8.68	8.74	8.70
July	8.68	8.63	8.69	8.68	8.67	8.71	8.70	8.65	8.65	8.66
August	8.79	8.68	8.73	8.78	8.72	8.77	8.76	8.68	8.76	8.71
September	8.92	8.72	8.77	8.74	8.72	8.78	8.78	8.70	8.83	8.74
October	8.90	8.81	8.86	8.80	8.76	8.82	8.81	8.78	8.85	8.79
November	8.91	8.83	8.87	8.77	8.75	8.80	8.83	8.77	8.82	8.79
December	8.84	8.81	8.86	8.77	8.76	8.83	8.82	8.77	8.80	8.78
Total	8.81	8.73	8.80	8.74	8.73	8.78	8.79	8.72	8.73	8.74

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2004

Somatic Cell Counts

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	249	294	322	308	315	290	334	267	231	280
February	272	308	331	343	325	310	337	276	215	291
March	263	325	348	356	336	329	356	287	214	300
April	241	311	335	326	327	303	341	288	205	295
May	231	312	326	336	321	287	330	285	207	290
June	229	347	346	340	342	302	351	306	228	308
July	247	357	365	339	370	325	395	314	240	323
August	244	342	356	322	363	324	385	309	271	317
September	221	304	315	306	331	292	351	287	242	291
October	210	268	289	274	304	262	313	256	222	264
November	218	259	276	263	295	256	291	245	216	255
December	217	271	293	277	285	253	283	246	210	255
Total	236	308	325	316	326	295	339	281	223	289

Table A-3

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2004

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

SNF = c + b(BF)

Month	Coefficient	Standard Error	t Statistic	R-squared (Adjusted)
SNF = c + b(BF)				
Constant (c)	7.218242	0.012125		0.253
Butterfat (b)	0.390235	0.003178	122.803	
SNF = c + b(BF) + m(February) + . . . + m(December)				
Constant (c)	7.1622	0.006	1,160.797	0.257
Butterfat (b)	0.4102	0.002	264.657	
February	-0.0383	0.002	-19.787	
March	-0.0354	0.002	-18.334	
April	-0.0406	0.002	-20.947	
May	-0.0194	0.002	-10.009	
June	-0.0166	0.002	-8.505	
July	-0.0482	0.002	-24.471	
August	-0.0147	0.002	-7.510	
September	-0.0159	0.002	-8.145	
October	0.0069	0.002	3.536	
November	-0.0194	0.002	-10.003	
December	-0.0240	0.002	-12.324	

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

SNF = c + b(PRO)

Month	Coefficient	Standard Error	t Statistic	R-squared (Adjusted)
SNF = c + b(PRO)				
Constant (c)	5.411257	0.004974		0.649
Protein (b)	1.082361	0.001634	662.471	
SNF = c + b(PRO) + m(February) + . . . + m(December)				
Constant (c)	5.2386	0.005	981.650	0.667
Protein (b)	1.1421	0.002	668.770	
February	-0.0151	0.001	-11.655	
March	0.0076	0.001	5.887	
April	0.0154	0.001	11.813	
May	0.0264	0.001	20.277	
June	0.0319	0.001	24.375	
July	0.0106	0.001	8.058	
August	0.0053	0.001	4.046	
September	-0.0215	0.001	-16.529	
October	-0.0510	0.001	-39.117	
November	-0.0683	0.001	-52.322	
December	-0.0513	0.001	-39.326	

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2004

Butterfat Levels as a Predictor of Protein Levels

PRO = c + b(BF)

Month	Coefficient	Standard Error	t Statistic	R-squared (Adjusted)
PRO = c + b(BF)				
Constant (c)	1.598389	0.008042		0.426
Butterfat (b)	0.378875	0.002108	179.793	
PRO = c + b(BF) + m(February) + . . . + m(December)				
Constant (c)	1.6165	0.004	414.168	0.464
Butterfat (b)	0.3767	0.001	384.121	
February	-0.0203	0.001	-16.573	
March	-0.0371	0.001	-30.372	
April	-0.0478	0.001	-39.017	
May	-0.0382	0.001	-31.059	
June	-0.0393	0.001	-31.768	
July	-0.0475	0.001	-38.119	
August	-0.0141	0.001	-11.403	
September	0.0076	0.001	6.111	
October	0.0508	0.001	41.350	
November	0.0421	0.001	34.212	
December	0.0233	0.001	18.917	

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2004

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
January	5.227768	1.145627	0.005868	0.656507	0.138087
February	5.262704	1.129284	0.005854	0.652538	0.136707
March	5.183132	1.162940	0.005789	0.669155	0.129233
April	5.075661	1.200000	0.010000	0.693748	0.120760
May	5.162078	1.176452	0.005398	0.705334	0.111412
June	5.155314	1.180896	0.005895	0.669621	0.119477
July	4.909869	1.257350	0.006250	0.672116	0.122985
August	5.034144	1.212220	0.006175	0.661638	0.123058
September	5.120941	1.173846	0.006392	0.632305	0.130847
October	5.406721	1.072027	0.005909	0.627044	0.131115
November	5.490364	1.040041	0.005968	0.608671	0.141873
December	5.492667	1.044102	0.005711	0.631860	0.137063

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

SNF = c + b_1(PRO) +b_2(PRO)^2

Month	**c** Constant	**b_1** Protein Coefficient	Standard Error of **b_1**	**b_2** Protein Coefficient	Standard Error of **b_2**	R-squared (Adjusted)	Standard Error
January	-1.341000	5.313000	0.083000	-0.659000	0.013000	0.695550	0.130002
February	-0.815060	5.019694	0.086348	-0.620450	0.013742	0.684934	0.130178
March	-1.278670	5.350216	0.090724	-0.676260	0.014625	0.701167	0.122821
April	-1.637850	5.617050	5.617050	-0.724120	0.014887	0.726376	0.114146
May	-0.276520	4.748935	4.748935	-0.585120	0.015847	0.724267	0.107773
June	-0.703340	5.061583	5.061583	-0.640940	0.018445	0.688601	0.115994
July	-2.118690	5.969275	5.969275	-0.787800	0.018793	0.698878	0.117860
August	-1.252670	5.347543	5.347543	-0.678320	0.017839	0.684751	0.118781
September	-1.595990	5.522031	5.522031	-0.701780	0.018689	0.656955	0.126385
October	0.483923	4.143515	4.143515	-0.477560	0.016699	0.641986	0.128462
November	1.046156	3.797900	3.797900	-0.426260	0.014729	0.624749	0.138928
December	0.314770	4.260390	4.260390	-0.497380	0.013550	0.655668	0.132557

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2004

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
January	1.469922	0.414423	0.003250	0.449102	0.123683
February	1.474008	0.408148	0.003348	0.428502	0.125415
March	1.558775	0.382012	0.003397	0.387900	0.123647
April	1.707058	0.340379	0.003501	0.322787	0.124494
May	1.789274	0.320672	0.003550	0.291341	0.123342
June	1.765175	0.325827	0.003694	0.282111	0.122044
July	1.614829	0.364121	0.003586	0.342827	0.113529
August	1.658314	0.361489	0.003565	0.342782	0.115082
September	1.666298	0.365336	0.003473	0.360777	0.116871
October	1.632284	0.385696	0.003276	0.414583	0.121341
November	1.543317	0.406052	0.003168	0.456950	0.125371
December	1.530348	0.404592	0.003109	0.465085	0.125785

Butterfat Levels as a Predictor of Protein Levels

$$PRO = c + b_1(BF) + b_2(BF)^2$$

Month	**c** Constant	**b_1** Butterfat Coefficient	Standard Error of **b_1**	**b_2** Butterfat Coefficient	Standard Error of **b_2**	R-squared (Adjusted)	Standard Error
January	3.547775	-0.61839	-0.61839	0.127556	0.004464	0.470745	0.121229
February	3.607442	-0.65505	-0.65505	0.131690	0.004819	0.449231	0.123119
March	3.862717	-0.78282	-0.78282	0.146459	0.005250	0.410857	0.121306
April	3.976117	-0.82484	-0.82484	0.148874	0.005287	0.348791	0.122080
May	4.743221	-1.21058	-1.21058	0.197479	0.005727	0.331370	0.119808
June	5.030322	-1.40078	-1.40078	0.227224	0.006630	0.322285	0.118580
July	4.137783	-0.98713	-0.98713	0.180152	0.006629	0.366471	0.111468
August	4.346529	-1.06393	-1.06393	0.188127	0.006187	0.372200	0.112477
September	4.555382	-1.14376	-1.14376	0.196114	0.005603	0.398336	0.113385
October	4.614517	-1.10338	-1.10338	0.184798	0.004882	0.454484	0.117132
November	3.968693	-0.78032	-0.78032	0.144061	0.004282	0.486686	0.121890
December	4.161500	-0.88134	-0.88134	0.155952	0.004205	0.500360	0.121567

Table A-4

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

2004

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	($/Pound)			($/cwt. Per 1,000 SCC)
January	$1.4978	$2.0875	$0.0217	$0.00065
February	$1.8518	$1.7911	$0.0090	$0.00066
March	$2.3813	$2.0133	$0.0234	$0.00078
April	$2.5013	$3.4465	$0.1042	$0.00103
May	$2.4282	$3.7639	$0.1444	$0.00106
June	$2.1768	$3.1086	$0.1339	$0.00092
July	$2.0543	$2.3625	$0.1048	$0.00078
August	$1.7941	$2.4663	$0.0676	$0.00076
September	$1.9354	$2.5431	$0.0589	$0.00079
October	$1.9020	$2.3814	$0.0677	$0.00076
November	$2.0489	$2.4297	$0.0800	$0.00079
December	$2.0366	$2.8486	$0.0858	$0.00086
Simple Average	$2.0507	$2.6035	$0.0751	$0.00082

Table A-5

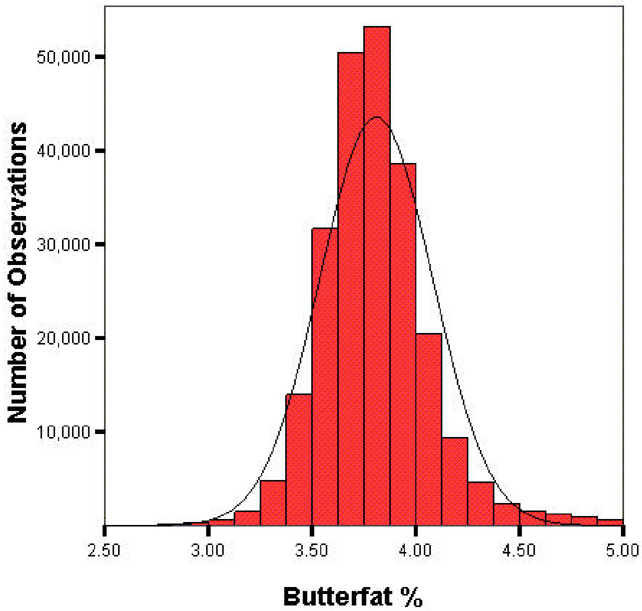
AGGREGATED COMPONENT VALUES BY SIZE RANGE OF MONTHLY PRODUCER MILK DELIVERIES

2004

Size Range: Equal to or more than (Pounds)	Size Range: Less than (Pounds)	Aggregated Component Values* ($)	Producer Milk (Pounds)	Weighted Average Value ($/Cwt.)
	20,000	$23,744,697.16	145,827,571	$16.28
20,000	30,000	$53,236,712.21	328,120,739	$16.22
30,000	50,000	$240,041,093.29	1,484,836,348	$16.17
50,000	70,000	$385,938,524.68	2,388,818,888	$16.16
70,000	100,000	$642,530,962.93	3,980,522,144	$16.14
100,000	150,000	$791,427,952.85	4,912,043,794	$16.11
150,000	250,000	$762,742,270.67	4,732,268,393	$16.12
250,000	400,000	$491,251,819.00	3,048,497,434	$16.11
400,000		$2,247,846,454.32	14,155,134,596	$15.88
Total		$5,638,760,487.10	35,176,069,907	
Weighted Average				$16.03

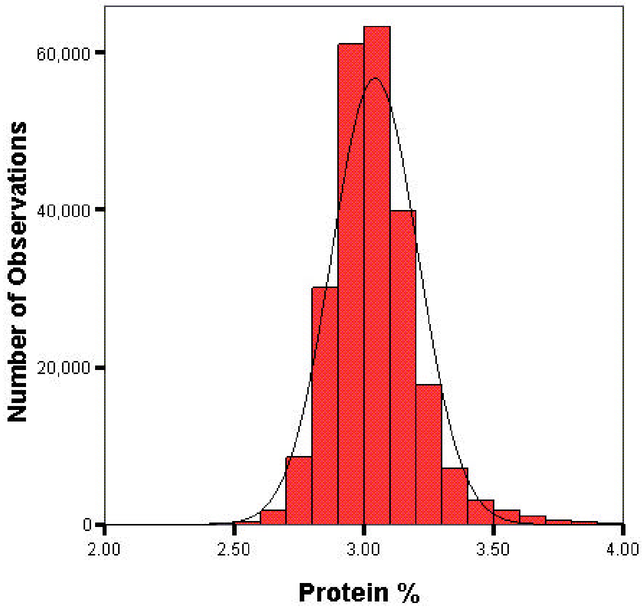
* Total value of pounds of butterfat, protein, and other solids, adjusted for SCC.

Figure A-1
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE BUTTERFAT LEVELS, 2004



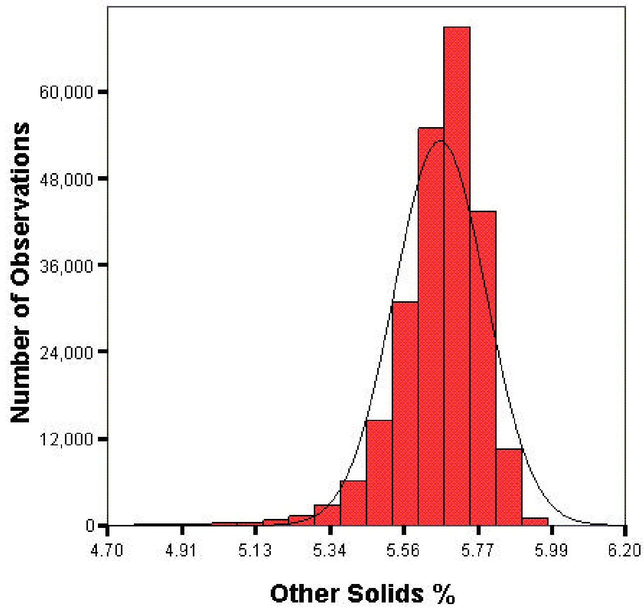
Skewness statistic: 0.861
Kurtosis statistic: 4.460

Figure A-2
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE PROTEIN LEVELS, 2004



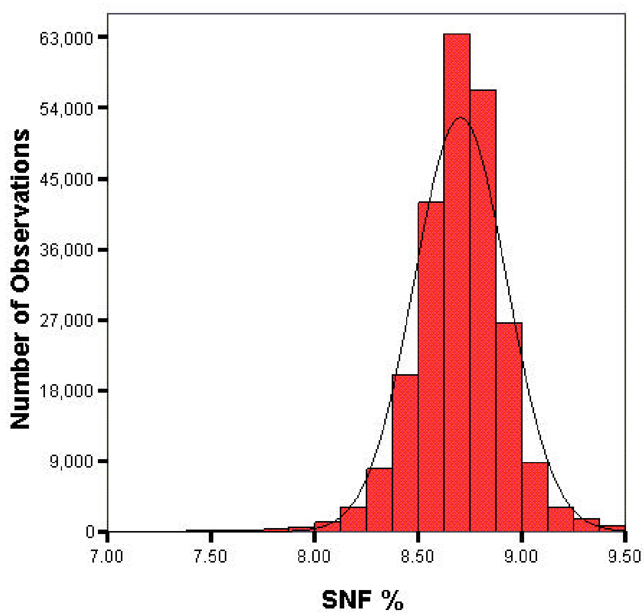
Skewness statistic: 0.695
Kurtosis statistic: 5.651

Figure A-3
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE OTHER SOLIDS LEVELS, 2004



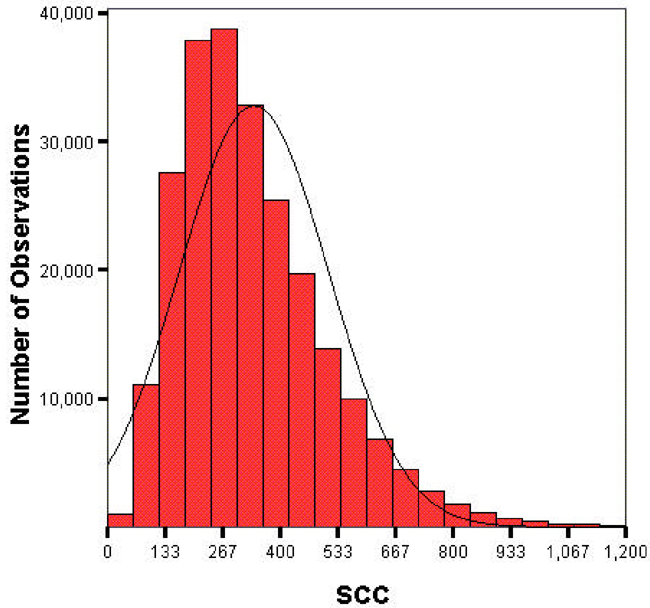
Skewness statistic: -4.46
Kurtosis statistic: 87.280

Figure A-4
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOLIDS-NOT-FAT LEVELS, 2004



Skewness statistic: -1.559
Kurtosis statistic: 23.151

Figure A-5
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOMATIC CELL COUNT, 2004



Skewness statistic: 1.534
Kurtosis statistic: 6.066

Figure A-6
WEIGHTED AVERAGE MONTHLY BUTTERFAT TESTS
2000, 2001, 2002, 2003, & 2004

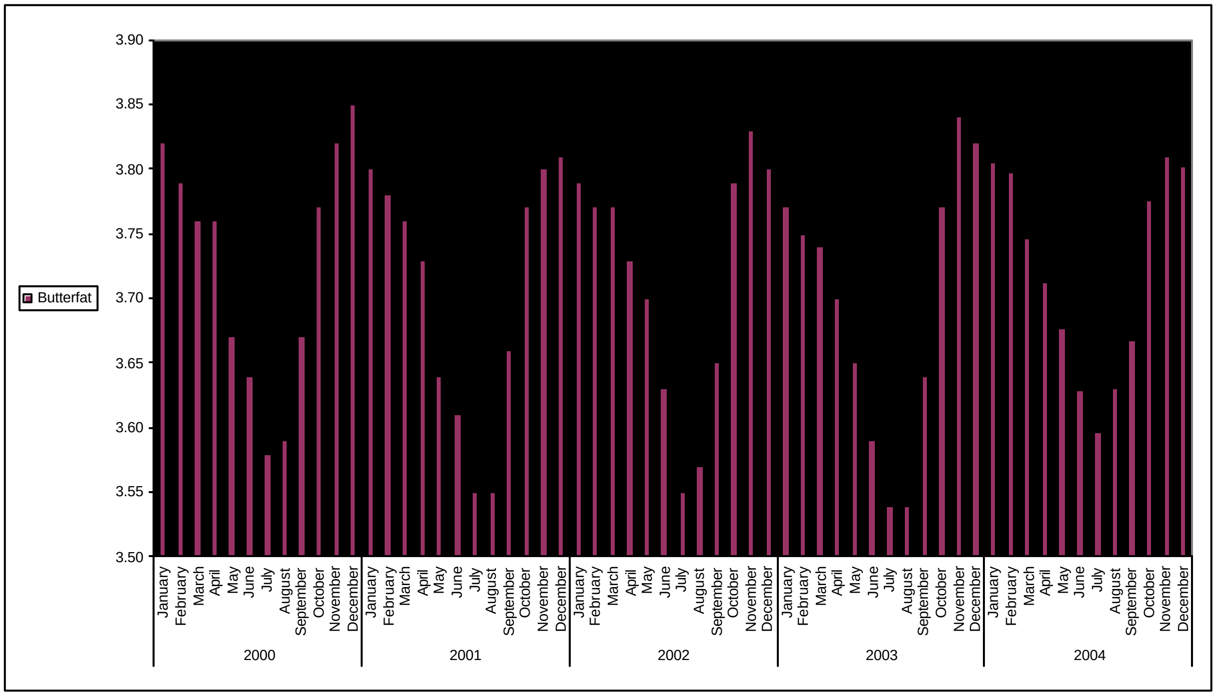


Figure A-7
WEIGHTED AVERAGE MONTHLY PROTEIN TESTS
2000, 2001, 2002, 2003, & 2004

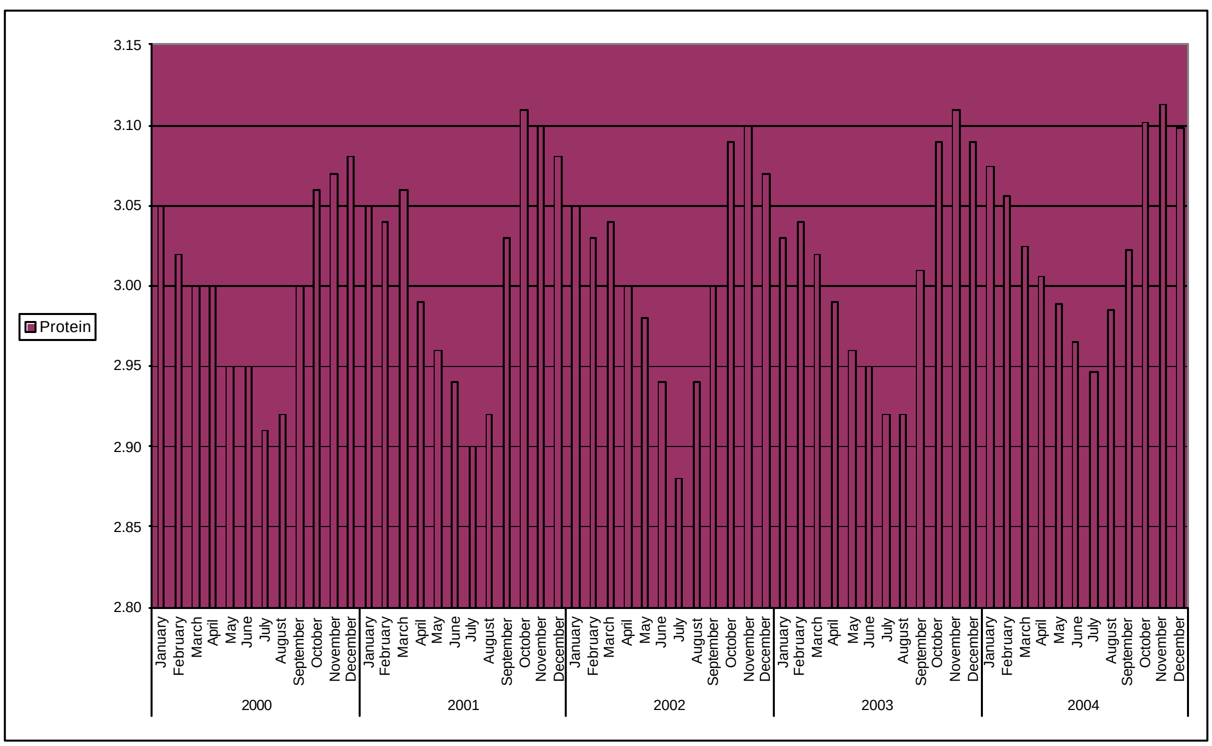


Figure A-8
WEIGHTED AVERAGE MONTHLY OTHER SOLIDS TESTS
2000, 2001, 2002, 2003, & 2004

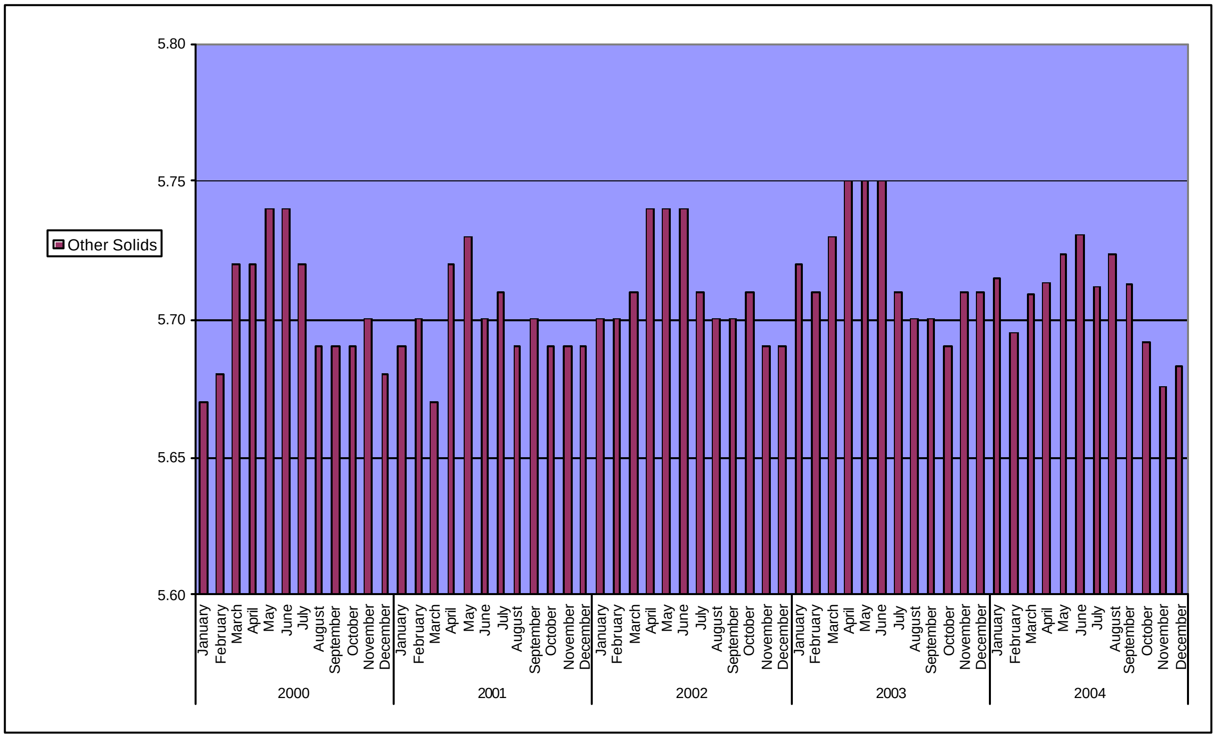


Figure A-9
WEIGHTED AVERAGE MONTHLY SOLIDS-NOT-FAT TESTS
2000, 2001, 2002, 2003, & 2004

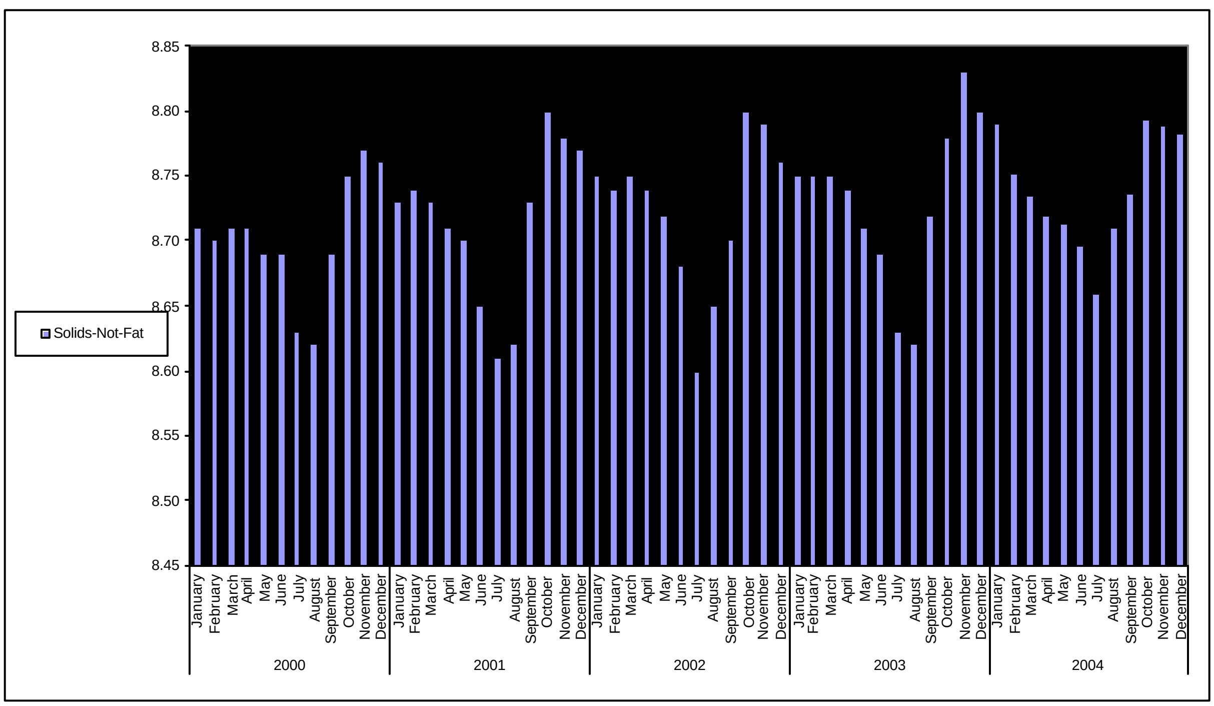


Figure A-10
WEIGHTED AVERAGE MONTHLY SOMATIC CELL COUNTS
2000, 2001, 2002, 2003, & 2004