UPPER MIDWEST MARKETING AREA

ANALYSIS OF COMPONENT LEVELS AND SOMATIC CELL COUNT IN INDIVIDUAL HERD MILK AT THE FARM LEVEL 2003

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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 2003. 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 2003 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 2003 were 3.69% butterfat, 3.01% protein, 5.72% other solids, 8.73% SNF and 312,000 SCC.

2) For 2003, weighted average butterfat, protein and SNF levels were lowest in July and August and highest during the late fall and winter. In contrast, other solids levels varied little during the year. Weighted average SCC were lowest in the winter and highest in 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 2003, the range of weighted average component levels within one standard deviation of the mean was: 3.45% to 3.94% for butterfat; 2.87% to 3.15% for protein; 5.61% to 5.84% for other solids; 8.54% to 8.92% for SNF; and 167,000 to 456,000 for SCC.

5) Based on the data for 2003, the following regression equations were derived:

$$SNF = 7.13098\% + 0.41596\ (BF)$$
$$SNF = 5.30149\% + 1.12321\ (PRO)$$
$$PRO = 1.56388\% + 0.38754\ (BF)$$

5) The annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $11.75 per cwt. for the market in 2003. Protein was the most valuable component, contributing a little more than half of the total value.

TABLE OF CONTENTS

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

2003

Corey Freije [1]

I. INTRODUCTION

The data for this study were collected for milk marketed in 2003 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 2003 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 monthly 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 States of Idaho and Utah. 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 2003, 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 2003 appeared to be consistent with historical changes. 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 2003 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

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	5.70	8.78	290
November	3.84	3.12	5.71	8.83	274
December	3.82	3.09	5.71	8.80	277
Minimum	3.54	2.92	5.70	8.62	274
Maximum	3.84	3.12	5.75	8.83	348
Annual Average	3.69	3.01	5.72	8.73	312

During the year, butterfat levels dropped from 3.77% in January to 3.54% in July, then rose to 3.84% by November. Protein and SNF showed similar seasonal patterns during the year by bottoming out in the summer and peaking by year-end. The standard deviation for butterfat, protein and SNF was 0.25, 0.14 and 0.11 percentage points, respectively. Other solids demonstrated the narrowest range of variation with no apparent seasonal pattern. Other solids levels ranged from a high of 5.75% in April, May and June to a low of 5.70% in August, September and October. The seasonal high SCC of 348,000 was reached in August before dropping to 274,000 in November, a change of 74,000 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 2003, the simple average SCC (354,000) was higher than the weighted average (312,000) indicating that larger producers tended to have, on average, lower SCC than their smaller counterparts. These numbers indicate 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 1.408. 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 Minimum and Maximum

2003

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -
Butterfat	3.69	3.77	0.25	1.58	9.29
Protein	3.01	3.03	0.14	1.37	5.38
Other Solids	5.72	5.67	0.11	.55	7.40
SNF	8.73	8.70	0.19	3.44	10.70
SCC (1,000's)	312	354	144	0	4,560

The range of component levels observed in the data was fairly wide. Individual monthly average butterfat levels in the data were as low as 1.58% and as high as 9.29%; protein levels ranged from 1.37% to 5.38%; other solids levels ranged from .55% to 7.40%; SNF levels ranged from 3.44% to 10.70%; and SCC ranged from 0 to 4,560,000.

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: 3.45% to 3.94% for butterfat; 2.87% to 3.15% for protein; 5.61% to 5.84% for other solids; 8.54% to 8.92% for SNF; and 167,000 to 456,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2003 data were within these ranges[7] (see also Appendix Table A-2 and Appendix Figures A-1 through A-5).

[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 2003 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.

The differences in the weighted and simple averages of the component tests warrant a closer look at the relationship between farm size, based on monthly average milk marketed, and milk component levels. Producers with marketings for each month of 2003 were divided into 10 percentiles, 10 groups with the same cumulative production. The monthly average production and component tests are shown in Table 3.

Table 3

Weighted Average Component Tests by Monthly Average Producer Milk Production

2003

Percentile	Monthly Average Pounds	Butterfat Test	Protein Test	Other Solids Test	Solids Not Fat Test	Somatic Cell Count
		- % -	- % -	- % -	- % -	- 1,000 -
1	18,837	3.87	3.07	5.57	8.64	427
2	35,954	3.83	3.05	5.62	8.67	405
3	48,224	3.81	3.04	5.64	8.68	385
4	59,781	3.79	3.03	5.66	8.69	370
5	71,917	3.77	3.02	5.68	8.70	352
6	85,684	3.76	3.01	5.69	8.71	341
7	103,021	3.74	3.01	5.70	8.71	333
8	128,558	3.74	3.01	5.72	8.72	323
9	180,105	3.73	3.01	5.72	8.73	308
10	690,327	3.62	3.00	5.75	8.75	281
Average	142,241	3.69	3.01	5.72	8.73	312

Monthly Average Producer Milk by Producer Size
2003

Percentile	Number of Producers	Monthly Average Pounds	Minimum Monthly Pounds	Maximum Monthly Pounds	Total Pounds	Percent of Total Pounds	Cumulative Percent of Total
1	23,282	18,837	140	29,065	438,570,513	1.3	
2	23,281	35,954	29,066	42,339	837,048,266	2.5	3.9
3	23,282	48,224	42,340	53,975	1,122,761,586	3.4	7.2
4	23,281	59,781	53,977	65,694	1,391,761,670	4.2	11.4
5	23,284	71,917	65,695	78,333	1,674,508,860	5.1	16.5
6	23,280	85,684	78,334	93,599	1,994,731,550	6.0	22.5
7	23,284	103,021	93,600	113,875	2,398,735,961	7.2	29.8
8	23,281	128,558	113,876	146,781	2,992,953,678	9.0	38.8
9	23,282	180,105	146,785	232,428	4,193,208,055	12.7	51.5
10	23,282	690,327	232,430	25,466,803	16,072,193,434	48.5	100.0
Total or Average	232,819	142,241			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 18,837 pounds per month had an average butterfat test of 3.87% while producers averaging 690,327 pounds averaged a 3.62% butterfat test. The SCC declined steadily from an average of 427,000 for producers averaging 18,837 pounds per month to an average of 281,000 for producers averaging 690,327 pounds per month, a difference in the SCC of 146,000.

Protein tests also declined from the smaller producers to the larger producers but to a smaller extent than for butterfat, falling from 3.07% for producer's averaging 18,837 pounds per month to 3.00% for producers averaging 690,327 pounds per month. It is interesting to note that the protein test dropped off fairly rapidly and then leveled off for most of the size groups.

Other solids and solids-not-fat tests steadily increased as average monthly production increased. Other solids tests increased from 5.57% to 5.75%, while solids-not-fat tests increased steadily from 8.64% to 8.75% as monthly average production increased over it's range.

The data from this group of producers also offers some interesting insight into the structure of the market. For instance, the smallest of producers averaging 18,837 pounds per month and comprising 10 percent of producers supply less than one and a half percent of the milk while the largest ten percent of producers supply nearly 50 percent of the milk in the market. There are approximately 80 percent of the producers with monthly production below the monthly average market production of 142,241 pounds.

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

Milk component levels and SCC were examined for the eighteen states that reported producers to Federal Order 30 (see Table 4). 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 differences 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, Iowa had the highest weighted average butterfat test and the highest weighted average protein test. North Dakota had the highest weighted average other solids tests, while Iowa had the highest weighted average SNF test for states included on Order 30. Of the states that are included in the Upper Midwest Marketing area Wisconsin had the lowest weighted average SCC and Minnesota had the highest. Detailed state information by month for 2003 is presented in Table A-2 (see Appendix).

Table 4

Weighted Average Components Levels and Somatic Cell Count in Milk by State 2003

State	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
Idaho	3.57	3.04	5.74	8.78	254
Illinois	3.75	3.02	5.70	8.72	327
Iowa	3.76	3.10	5.76	8.86	348
Michigan	3.64	3.03	5.74	8.77	338
Minnesota	3.71	3.02	5.72	8.75	356
North Dakota	3.66	3.04	5.77	8.80	312
South Dakota	3.73	3.05	5.74	8.79	376
Other[8]	3.54	3.04	5.76	8.80	239
Wisconsin	3.71	2.99	5.71	8.71	300
Market	3.69	3.01	5.72	8.73	312
Minimum	3.54	2.99	5.70	8.71	239
Maximum	3.76	3.10	5.77	8.86	356

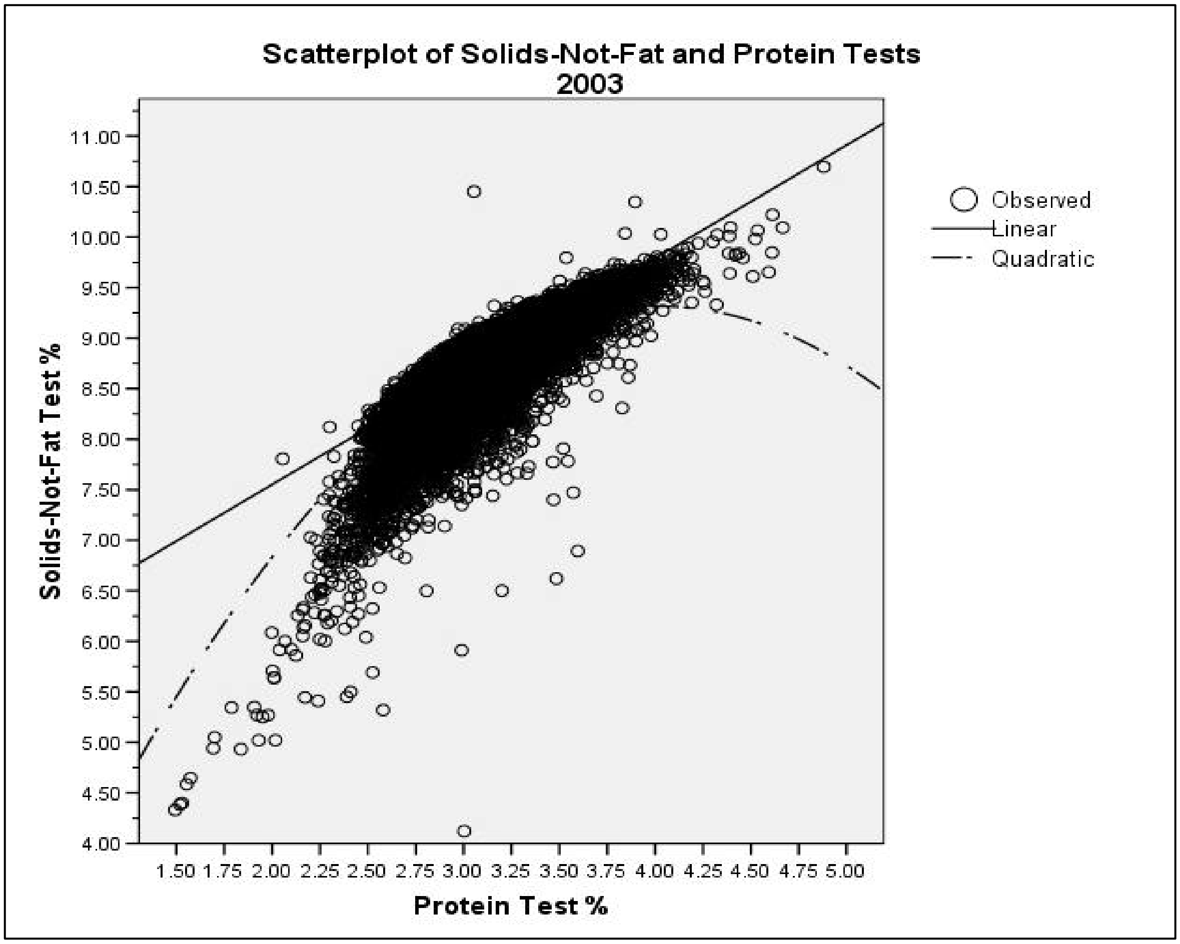
IV. STATISTICAL RELATIONSHIPS AMONG MILK COMPONENTS

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 tests, Figure 1, one can see a vaguely convex relationship between the two. 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

[8] Other includes milk from Indiana, Kansas, Missouri, Montana, Nebraska, Ohio, Oregon, South Carolina, Utah and Washington.

butterfat and protein and solids-not-fat and protein than the linear model. For consistency with past studies, a dscussion 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



Regression analysis was used to estimate the linear relationship between components. Results from the 2003 data were compared with results from previous Upper Midwest Order studies (1993-2002), 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 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 fifteen 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 2003 data was within that range at 0.41596. 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 = 7.13098% + 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 2003 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, on page 9, is a scatter plot of monthly average producer solids-not-fat and protein tests for 2003. 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:

$$\text{Solids-not-fat Test} = 5.3015 + 1.1232 * \text{Protein Test},$$

while the equation for the quadratic model is:

$$\text{Solids-not-fat Test} = -0.5326 + (4.9036 * \text{Protein Test}) + (-0.6104 * (\text{Protein Test})^2).$$

The R-squared for the linear model is 0.591 while the R-squared for the quadratic model is 0.675. 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 = 5.30149% + 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 2002 data and those of Halverson/Kyburz (see Table 7). The primary observation from the equation derived for the 2003 data was that the constant of 1.56388 and coefficient of 0.38754 for the independent variable were approximately the same as for the 2002 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 = 1.56388% + 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 2003. 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:

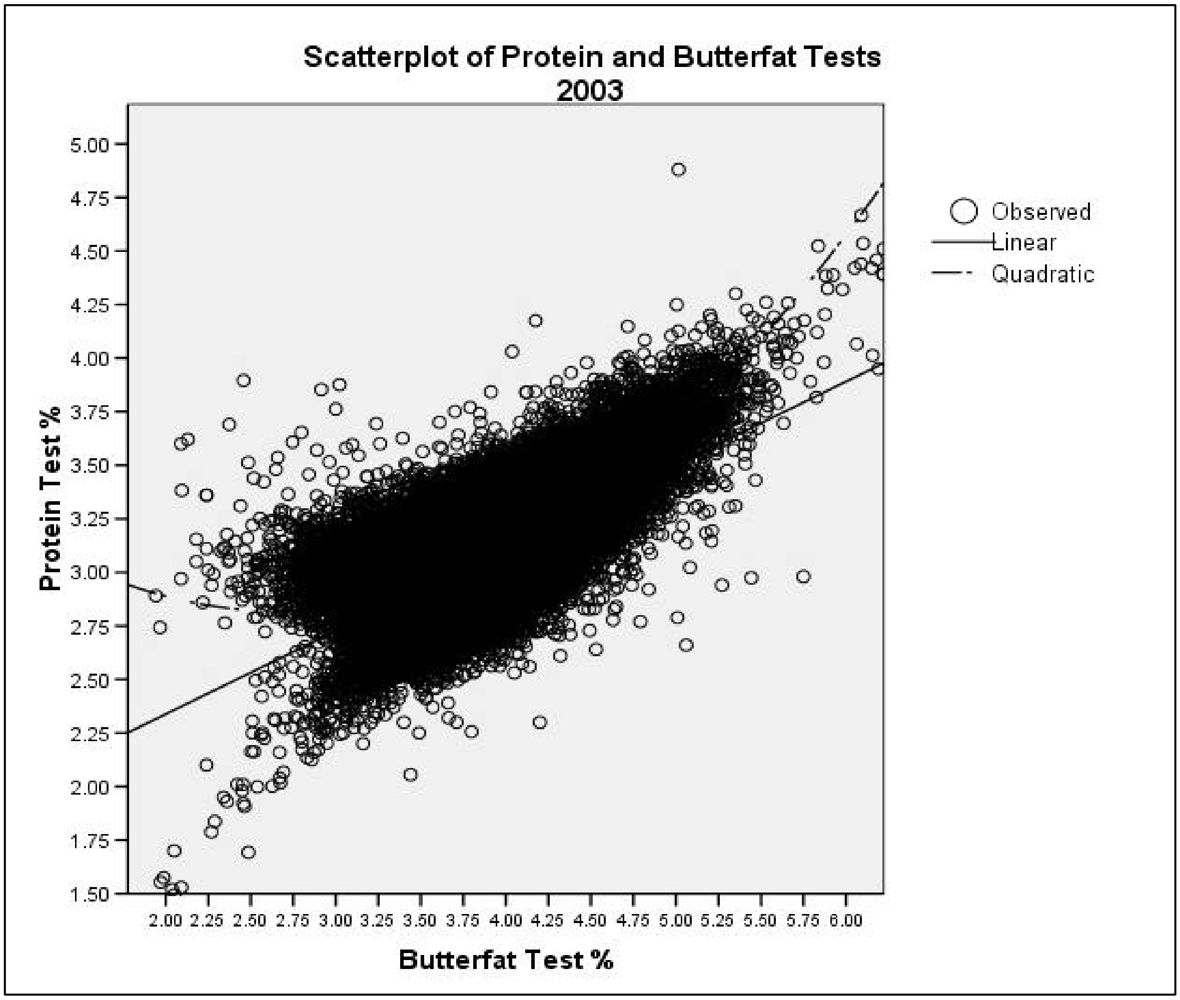
$$\textit{Protein Test} = 1.5639 + 0.3875 * \textit{Butterfat Test},$$

while the equation for the quadratic model is:

$$\textit{Protein Test} = 3.5825 + (-0.6548 * \textit{Butterfat Test}) + (0.1337 * (\textit{Butterfat Test})^2).$$

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 2003, has a slightly higher adjusted R-squared of 0.448, versus 0.425 for the linear model, suggesting a slightly better fit. The remaining months of 2003 had a similar difference in the R-squared value between the linear model and the quadratic model.

Figure 2



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 0.68 suggests that a moderately strong linear relationship exists while protein and SNF appears to have a strong relationship with a coefficient of 0.81. 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.

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.

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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.

The regression equations include simple linear equations, quadratic equations, 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 $$Y ? ? ? ?_1 X ? ?_2 D_{jan} ? \; ? ?_{13} D_{dec} ? ?$$

which has an equivalent representation as:

$$Y ? ?_c ? ?_1 D_{jan} ? ? \; ?_{11} D_{nov} ? ?X ? ?$$

Where the equivalency comes in as:

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

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.

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.

$$Y ? ?_c ? ?_1 X_{jan} ? ? \; ? ?_{12} X_{dec} ? ?$$

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

The F-Test

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

$$F(232830, 213135) ? \frac{(.262 ? .229) / 232830}{(1 ? .262) / 213135} ? 611.289$$

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.

The Lagrange Multiplier Test

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

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.

Months $LM = 19.716$

States $LM = 1.9733$

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_{xx}^{t} is the sum of the squared x's for the dataset and S_{xx}^{w} 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

$$b^{t} \; ? \; mb^{w} \; ? \; (1 \; ? \; m)b^{b}.$$

For the monthly data the calculations are:

$$m \; ? \; \frac{1.12 \; ? \; 1.62}{.867 \; ? \; 1.62} \; ? \; \frac{.5}{.753} \; ? \; .664$$

For the state data the calculations are:

$$m \; ? \; \frac{1.12 \; ? \; 4.18}{.7079 \; ? \; 4.18} \; ? \; \frac{3.06}{3.4721} \; ? \; .8813$$

As you can see, most of the variation in the data is within the month and within the state 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 2003. 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 2003, the cumulative value of butterfat, protein, other solids and an adjustment for SCC averaged $11.75 per cwt. for the market. The value of each component comprised by the $11.75 per cwt. price was $4.47 for butterfat, $7.18 for protein, and $0.073 for other solids. The SCC adjustment for the year amounted to about $0.025 per cwt.

Categorized by size range of delivery, average values of producer milk ranged from a low of $11.57 per cwt. for monthly producer milk deliveries greater than 400,000 pounds to a high of $12.11 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 - 2003 WEIGHTED AVERAGE COMPONENT TESTS

Weighted average component data for the past four years, 2000, 2001, 2002 and 2003, are shown in Table 8. Over these three years the yearly average tests have changed very little. Yearly average butterfat tests were 3.73 percent, 3.70 percent, 3.72 percent and 3.69 percent for 2000, 2001, 2002 and 2003 respectively. Yearly average protein and other solids tests varied even less than the butterfat test with only a .01 percent difference between the four years. Yearly weighted average somatic cell counts also did not change much over the four-year period, increasing slightly from 2000 to 2001 and then declining from 336,000 in 2001 to 326,000 in 2002 and to 312,000 in 2003.

Graphs (see Appendix Figures A-6 through A-10) show the monthly weighted average component tests for 2000, 2001, 2002, and 2003. 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 and 2003 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 8

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 8 (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	5.70	8.78	290
November	3.84	3.12	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

VII. SUMMARY

This staff paper analyzes milk components and SCC in producer milk associated with the Upper Midwest Order during 2003. 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 2003 were: 3.69% butterfat, 3.01% protein, 5.72% other solids, 8.73% SNF and 312,000 SCC. Weighted average butterfat, protein and SNF levels were lowest in July and August and highest in the late fall and winter. The weighted monthly average levels of other solids were highest in April, 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 highest in August. Approximately three-quarters of monthly average component levels ranged from: 3.45% to 3.94% for butterfat; 2.87% to 3.15% for protein; 5.61% to 5.84% for other solids; 8.54% to 8.92% for SNF; and 167,000 to 456,000 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 of producers averaging 18,837 pounds per month and comprising 10 percent of producers supply less than two percent of the milk while the largest ten percent of producers supply nearly 50 percent of the milk in the market. There are approximately 80 percent of the producers with monthly production below the monthly average market production of 142,241 pounds.

Based on the data for 2003, the following regression equations were derived:

$$SNF = 7.13098\% + 0.41596\ (BF)$$
$$SNF = 5.30149\% + 1.12321\ (PRO)$$
$$PRO = 1.56388\% + 0.38754\ (BF)$$

Under MCP, the annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $11.75 per cwt. for the market. Protein contributed more 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

2003

Butterfat

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Skew ness	Minimum	Maximum	Number of Observations
	- % -	- % -	- % -	- % -	- % -	- % -	
January	3.77	3.85	0.24	0.93	1.96	6.22	19,500
February	3.75	3.84	0.24	0.86	2.09	6.10	19,416
March	3.74	3.83	0.24	0.81	1.97	6.09	19,473
April	3.70	3.79	0.23	0.76	1.99	5.56	19,238
May	3.65	3.73	0.23	0.68	2.13	5.30	19,211
June	3.59	3.65	0.22	0.69	2.09	5.26	19,165
July	3.54	3.59	0.20	0.73	2.40	5.65	19,280
August	3.54	3.58	0.20	0.70	1.42	5.19	19,906
September	3.64	3.71	0.22	0.83	2.11	5.29	19,701
October	3.77	3.86	0.24	1.07	2.41	5.82	19,726
November	3.84	3.93	0.25	1.09	1.35	6.00	19,830
December	3.82	3.90	0.24	1.17	1.53	6.23	19,726
For the Year	3.69	3.77	0.25	.79	1.35	6.23	232,819

Protein

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Skew ness	Minimum	Maximum	Number of Observations
	- % -	- % -	- % -	% -	- % -	- % -	
January	3.03	3.05	0.13	3.04	1.37	4.51	19,500
February	3.04	3.05	0.12	3.02	1.53	4.54	19,416
March	3.02	3.03	0.12	3.03	1.55	4.44	19,473
April	2.99	3.00	0.12	0.90	1.57	4.09	19,238
May	2.96	2.98	0.11	0.86	2.04	3.95	19,211
June	2.95	2.97	0.11	0.94	2.01	3.97	19,165
July	2.92	2.97	0.11	0.84	1.79	3.92	19,266
August	2.92	2.93	0.11	0.71	1.93	3.90	19,145
September	3.01	3.03	0.12	0.94	2.01	4.08	19,321
October	3.09	3.12	0.13	1.16	1.70	4.52	19,217
November	3.12	3.13	0.13	1.12	1.52	4.67	19,863
December	3.09	3.10	0.13	1.19	1.49	4.88	20,004
For the Year	3.01	3.03	0.14	0.87	1.37	4.88	232,819

Table A-1 (continued)

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

2003

Other Solids

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Skewness - % -	Minimum - % -	Maximum - % -	Number of Observations
January	5.72	5.67	0.10	-2.29	2.48	6.26	19,500
February	5.71	5.66	0.10	-1.74	2.87	7.39	19,416
March	5.73	5.68	0.10	-2.07	3.00	6.00	19,473
April	5.75	5.71	0.10	-4.25	0.57	6.12	19,238
May	5.75	5.70	0.10	-2.46	3.88	6.16	19,211
June	5.75	5.70	0.10	-7.22	0.55	6.19	19,165
July	5.71	5.66	0.10	-1.88	3.30	6.08	19,266
August	5.70	5.64	0.10	-2.46	1.12	6.00	19,145
September	5.70	5.64	0.11	-1.98	3.55	6.06	19,321
October	5.70	5.64	0.11	-2.79	2.92	5.98	19,217
November	5.71	5.66	0.10	-2.83	2.74	6.08	19,863
December	5.71	5.66	0.10	-2.69	2.84	6.45	20,004
For the Year	5.72	5.67	0.10	-2.78	0.55	7.39	232,819

Solids-Not-Fat

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Skewness - % -	Minimum - % -	Maximum - % -	Number of Observations
January	8.75	8.72	0.17	-0.69	3.85	10.03	19,500
February	8.75	8.72	0.17	-0.67	4.40	10.45	19,416
March	8.75	8.72	0.17	-0.77	4.58	9.89	19,473
April	8.74	8.71	0.17	-1.40	3.51	9.79	19,238
May	8.71	8.68	0.16	-1.16	5.92	9.68	19,211
June	8.69	8.68	0.16	-2.28	3.44	10.04	19,165
July	8.63	8.59	0.16	-0.96	5.25	9.50	19,266
August	8.62	8.57	0.17	-1.15	4.12	9.55	19,145
September	8.72	8.68	0.17	-0.83	5.64	9.83	19,321
October	8.78	8.76	0.17	-1.04	5.05	10.02	19,217
November	8.83	8.80	0.18	-1.06	4.38	10.09	19,863
December	8.80	8.76	0.18	-0.99	4.33	10.70	20,004
For the Year	8.73	8.70	0.18	-0.89	3.44	10.70	232,819

Table A-1 (continued)

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

2003

Somatic Cell Count

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Skewness	Minimum	Maximum	Number of Observations
	(1,000)						
January	301	343	141	1.47	0	2,278	19,500
February	314	358	150	1.49	26	2,809	19,416
March	316	362	152	1.49	0	2,760	19,473
April	308	354	147	1.32	0	3,071	19,238
May	315	356	146	1.84	0	4,560	19,211
June	322	360	141	1.24	0	1,953	19,165
July	345	394	152	1.26	0	4,105	19,266
August	348	397	151	1.26	0	3,689	19,145
September	330	374	143	1.14	19	2,222	19,321
October	290	324	126	1.30	20	2,305	19,217
November	274	312	126	1.52	11	2,389	19,863
December	277	319	132	1.56	17	2,283	20,004
For the Year	312	354	144	1.41	0	4,560	232,819

Table A-2

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE 2003

Butterfat

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.59	3.86	3.83	3.73	3.77	3.73	3.80	3.78	3.58	3.77
February	3.58	3.85	3.81	3.77	3.76	3.70	3.77	3.77	3.64	3.75
March	3.54	3.83	3.78	3.85	3.74	3.72	3.76	3.75	3.60	3.74
April	3.55	3.76	3.72	3.82	3.70	3.66	3.70	3.72	3.49	3.70
May	3.52	3.70	3.67	3.56	3.66	3.61	3.67	3.66	3.49	3.65
June	3.45	3.63	3.61	3.54	3.61	3.55	3.63	3.60	3.59	3.59
July	3.45	3.57	3.60	3.52	3.57	3.51	3.59	3.55	3.50	3.54
August	3.44	3.56	3.59	3.51	3.56	3.48	3.57	3.55	3.46	3.54
September	3.54	3.67	3.69	3.55	3.66	3.63	3.70	3.64	3.48	3.64
October	3.63	3.82	3.83	3.64	3.78	3.72	3.83	3.79	3.51	3.77
November	3.76	3.91	3.88	3.70	3.85	3.82	3.92	3.84	3.53	3.84
December	3.74	3.88	3.88	3.80	3.82	3.81	3.87	3.82	3.60	3.82
For the Year	3.57	3.75	3.76	3.64	3.71	3.66	3.73	3.71	3.54	3.69

Protein

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.04	3.06	3.12	3.09	3.04	3.05	3.07	3.02	3.13	3.03
February	3.04	3.05	3.13	3.11	3.05	3.07	3.08	3.03	3.12	3.04
March	3.04	3.03	3.11	3.10	3.04	3.06	3.06	3.00	3.10	3.02
April	3.01	3.00	3.07	3.07	3.00	3.01	3.01	2.98	3.07	2.99
May	2.99	2.98	3.05	3.00	2.98	2.97	2.99	2.95	3.04	2.96
June	2.94	2.96	3.02	3.00	2.96	2.95	2.98	2.94	3.00	2.95
July	2.91	2.91	2.98	2.97	2.94	2.93	2.95	2.91	2.96	2.92
August	2.94	2.90	2.99	2.93	2.95	2.97	2.97	2.90	2.96	2.92
September	3.06	3.01	3.10	3.01	3.04	3.08	3.08	2.99	3.01	3.01
October	3.11	3.12	3.18	3.05	3.09	3.12	3.13	3.08	3.05	3.09
November	3.19	3.13	3.18	3.04	3.12	3.17	3.17	3.09	3.08	3.12
December	3.15	3.10	3.16	3.05	3.09	3.11	3.14	3.07	3.08	3.09
For the Year	3.04	3.02	3.10	3.03	3.02	3.04	3.05	2.99	3.04	3.01

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE 2003

Other Solids

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	5.73	5.71	5.78	5.71	5.72	5.76	5.74	5.71	5.76	5.72
February	5.74	5.71	5.77	5.70	5.72	5.75	5.74	5.70	5.72	5.71
March	5.79	5.72	5.78	5.69	5.73	5.78	5.76	5.72	5.76	5.73
April	5.75	5.73	5.81	5.73	5.76	5.81	5.78	5.74	5.80	5.75
May	5.75	5.73	5.80	5.77	5.74	5.80	5.77	5.74	5.80	5.75
June	5.75	5.74	5.80	5.79	5.74	5.79	5.76	5.75	5.80	5.75
July	5.73	5.70	5.74	5.76	5.69	5.74	5.72	5.72	5.72	5.71
August	5.73	5.68	5.73	5.73	5.69	5.74	5.71	5.70	5.76	5.70
September	5.75	5.68	5.74	5.73	5.70	5.74	5.71	5.70	5.78	5.70
October	5.71	5.67	5.75	5.74	5.70	5.74	5.71	5.69	5.75	5.70
November	5.72	5.69	5.74	5.73	5.72	5.76	5.73	5.70	5.77	5.71
December	5.73	5.70	5.73	5.72	5.74	5.77	5.75	5.70	5.78	5.71
For the Year	5.74	5.70	5.76	5.74	5.72	5.77	5.74	5.71	5.76	5.72

Solids-Not-Fat

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	8.78	8.77	8.90	8.80	8.77	8.81	8.81	8.73	8.89	8.75
February	8.78	8.76	8.90	8.81	8.77	8.83	8.82	8.73	8.84	8.75
March	8.83	8.75	8.88	8.79	8.77	8.84	8.82	8.72	8.86	8.75
April	8.76	8.74	8.88	8.80	8.76	8.82	8.79	8.73	8.87	8.74
May	8.74	8.71	8.84	8.78	8.72	8.76	8.76	8.69	8.84	8.71
June	8.68	8.70	8.82	8.78	8.70	8.74	8.74	8.68	8.80	8.69
July	8.63	8.61	8.73	8.73	8.63	8.67	8.67	8.62	8.68	8.63
August	8.68	8.58	8.72	8.66	8.64	8.70	8.68	8.60	8.73	8.62
September	8.81	8.70	8.84	8.74	8.74	8.82	8.79	8.68	8.79	8.72
October	8.82	8.79	8.93	8.80	8.80	8.86	8.84	8.76	8.81	8.78
November	8.91	8.82	8.92	8.77	8.84	8.93	8.90	8.80	8.85	8.83
December	8.88	8.79	8.89	8.78	8.83	8.88	8.89	8.76	8.86	8.80
For the Year	8.78	8.72	8.86	8.77	8.75	8.80	8.79	8.71	8.80	8.73

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE 2003

Somatic Cell Counts

	Idaho	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	265	314	354	421	340	260	331	287	232	301
February	257	330	374	413	349	277	347	306	239	314
March	256	336	358	410	352	290	364	305	231	316
April	243	320	343	398	347	282	358	298	219	308
May	262	323	349	331	357	333	366	303	227	315
June	259	329	367	333	370	341	396	309	257	322
July	270	367	411	347	405	377	448	331	230	345
August	281	373	390	346	406	370	443	334	311	348
September	260	350	379	338	389	348	424	318	243	330
October	242	296	321	295	331	298	362	281	225	290
November	218	283	295	264	316	288	343	265	225	274
December	236	291	316	283	320	278	338	264	243	277
For the Year	254	327	348	338	356	312	376	300	239	312

Table A-3

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2003

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

SNF = c + b(BF)

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.131	.006		1192.568	.000
	Butterfat Test	.416	.002	.479	263.113	.000

a Dependent Variable: Solids Not Fat Test

Coefficients(a,b)

SNF = c + b(BF) + m(February) + . . . + m(December)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.273	.006		1162.063	.000
	Butterfat Test	.37541	.002	.457	236.176	.000
	Feb	-.00955	.002	-.012	-4.919	.000
	Mar	.00247	.002	.003	1.265	.206
	Apr	.00080	.002	.001	.410	.682
	May	.00546	.002	.007	2.778	.005
	Jun	.00140	.002	.002	.708	.479
	Jul	-.07311	.002	-.089	-36.398	.000
	Aug	-.03492	.002	-.043	-17.600	.000
	Sep	-.01173	.002	-.014	-5.968	.000
	Oct	.03528	.002	.043	18.077	.000
	Nov	.01680	.002	.021	8.609	.000
	Dec	-.00528	.002	-.006	-2.703	.007

a Dependent Variable: Solids Not Fat Test

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2003

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

SNF = c + b(PRO)

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.301	.006		903.590	.000
	Protein Test	1.123	.002	.769	580.110	.000

a Dependent Variable: Solids Not Fat Test

Coefficients(a)

SNF = c + b(PRO) + m(February) + . . . + m(December)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.178	.006		918.629	.000
	Feb	-.006	.001	-.007	-4.588	.000
	Mar	.016	.001	.019	11.521	.000
	Apr	.046	.001	.056	34.111	.000
	May	.044	.001	.052	32.059	.000
	Jun	.050	.001	.060	36.596	.000
	Jul	.013	.001	.016	9.654	.000
	Aug	-.004	.001	-.005	-3.074	.002
	Sep	-.024	.001	-.028	-17.373	.000
	Oct	-.042	.001	-.050	-30.759	.000
	Nov	-.021	.001	-.025	-15.294	.000
	Dec	-.012	.001	-.015	-8.974	.000
	Protein Test	1.162	.002	.836	638.008	.000

a Dependent Variable: Solids Not Fat Test

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2003

Butterfat Levels as a Predictor of Protein Levels

PRO = c + b(BF)

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.564	.004		442.265	.000
	Butterfat Test	.388	.001	.652	414.531	.000

a Dependent Variable: Protein Test

Coefficients(a)

PRO = c + b(BF) + m(February) + . . . + m(December)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.676	.004		429.254	.000
	Feb	.004	.001	.007	3.415	.001
	Mar	-.011	.001	-.018	-8.682	.000
	Apr	-.029	.001	-.048	-23.375	.000
	May	-.028	.001	-.046	-22.486	.000
	Jun	-.013	.001	-.021	-10.218	.000
	July	-.033	.001	-.055	-26.206	.000
	Aug	-.030	.001	-.051	-24.078	.000
	Sep	.030	.001	.049	23.818	.000
	Oct	.065	.001	.108	52.456	.000
	Nov	.051	.001	.086	41.501	.000
	Dec	.027	.001	.046	21.950	.000
	Butterfat Test	.357	.001	.600	360.831	.000

a Dependent Variable: Protein Test

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2003

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	5.345227	1.107408	0.005730	0.657022	0.130590
February	5.202132	1.152306	0.005849	0.666552	0.130136
March	5.191576	1.162910	0.005968	0.661032	0.129518
April	5.028504	1.227505	0.006514	0.648627	0.132639
May	5.087033	1.207446	0.006159	0.666725	0.121505
June	5.059004	1.219185	0.006423	0.652806	0.122778
July	4.884860	1.266974	0.006699	0.649955	0.125998
August	4.884515	1.261156	0.007138	0.619821	0.135599
September	5.170323	1.157018	0.006865	0.595149	0.137720
October	5.383837	1.082811	0.006553	0.586886	0.143701
November	5.367484	1.095094	0.006024	0.624585	0.141510
December	5.318137	1.113068	0.006032	0.629960	0.142401

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	-0.40621	4.781651	0.084206	-0.58472	0.013372	0.687637	0.124625
February	-1.34470	5.347729	0.090819	-0.66995	0.014475	0.699673	0.123504
March	-1.83312	5.696834	0.095999	-0.72930	0.015415	0.695967	0.122662
April	-2.84119	6.393899	0.115150	-0.84571	0.018822	0.681987	0.126185
May	-2.54565	6.252647	0.118472	-0.83161	0.019504	0.695526	0.116136
June	-2.24128	6.052003	0.125698	-0.79785	0.020726	0.677711	0.118293
July	-3.66678	7.027865	0.126502	-0.96793	0.021228	0.684040	0.119706
August	-3.75493	7.090781	0.140449	-0.98107	0.023608	0.651263	0.129871
September	-2.41135	6.067299	0.131074	-0.79294	0.021140	0.622615	0.132966
October	-1.22506	5.224509	0.109049	-0.64686	0.017003	0.615806	0.138580
November	-1.03214	5.078351	0.092894	-0.61762	0.014376	0.656491	0.135364
December	-0.54045	4.793929	0.086338	-0.57601	0.013480	0.660896	0.136319

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2003

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	1.557731	0.387791	0.003380	0.402979	0.126112
February	1.590937	0.380304	0.003446	0.385478	0.125172
March	1.620435	0.368764	0.003417	0.374194	0.123038
April	1.732255	0.334586	0.003425	0.331594	0.120029
May	1.852027	0.302326	0.003526	0.276729	0.121047
June	1.903893	0.291153	0.003584	0.256094	0.119103
July	1.766382	0.322694	0.003544	0.300897	0.113306
August	1.763871	0.324012	0.003667	0.289632	0.115711
September	1.800554	0.331427	0.003496	0.317507	0.119228
October	1.681779	0.372339	0.003337	0.393156	0.123224
November	1.558152	0.400015	0.003159	0.446620	0.123993
December	1.472802	0.416063	0.003191	0.459402	0.122735

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	4.310706	-0.99479	0.038472	0.172536	0.004784	0.440294	0.122108
February	4.478165	-1.07980	0.042598	0.183577	0.005339	0.420722	0.121529
March	4.445362	-1.06623	0.043536	0.181263	0.005483	0.407422	0.119727
April	4.488084	-1.08548	0.043864	0.182029	0.005606	0.366291	0.116872
May	5.187099	-1.45182	0.043849	0.229550	0.005721	0.332628	0.116275
June	5.519289	-1.65048	0.045665	0.259467	0.006085	0.320525	0.113829
July	4.722911	-1.29300	0.043950	0.219757	0.005960	0.346956	0.109510
August	4.541077	-1.20179	0.045293	0.208667	0.006175	0.329587	0.112410
September	5.094466	-1.40660	0.042267	0.228159	0.005531	0.372723	0.114303
October	4.446386	-1.01796	0.039436	0.173799	0.004913	0.430231	0.119401
November	4.139916	-0.86716	0.036007	0.154495	0.004374	0.479301	0.120275
December	3.894589	-0.77823	0.036021	0.146287	0.004396	0.487740	0.119475

Table A-4

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

2003

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	($/Pound)			($/cwt. Per 1,000 SCC)
January	$1.1856	$1.8164	$0.0339	$0.00057
February	1.1373	1.8538	0.0240	0.00056
March	1.1459	1.6648	0.0206	0.00054
April	1.1503	1.8006	-0.0008	0.00055
May	1.1512	1.9275	-0.0144	0.00057
June	1.1576	1.9434	-0.0200	0.00057
July	1.2055	2.5480	-0.0124	0.00067
August	1.2514	3.1438	0.0026	0.00077
September	1.2218	3.3180	0.0170	0.00080
October	1.2553	3.2815	0.0311	0.00080
November	1.2877	2.9267	0.0368	0.00075
December	1.3688	2.2997	0.0362	0.00066
Simple Average	$1.2099	$2.3770	$0.0129	$0.00065

Table A-5

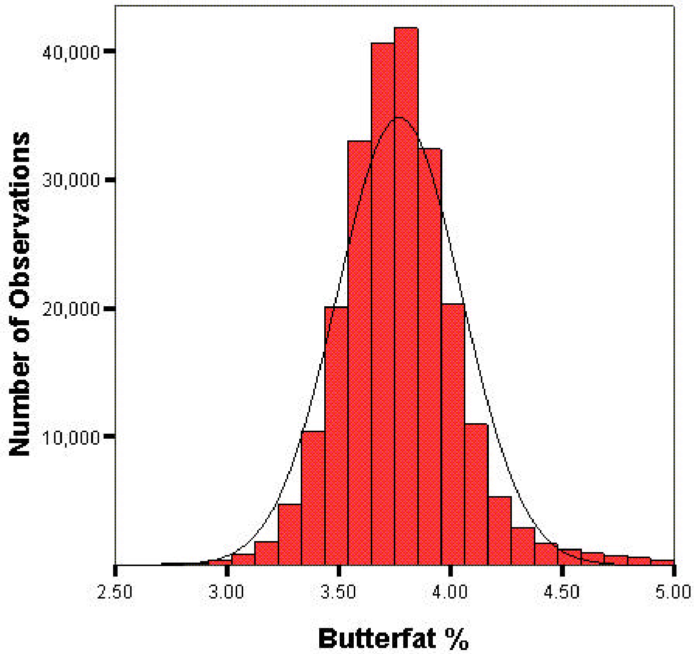
AGGREGATED COMPONENT VALUES BY SIZE RANGE OF MONTHLY PRODUCER MILK DELIVERIES

2003

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	$17,950,065	147,869,390	$12.11
20,000	30,000	40,370,554	334,235,652	12.02
30,000	50,000	178,483,933	1,494,020,300	11.92
50,000	70,000	280,964,592	2,367,478,819	11.86
70,000	100,000	463,219,003	3,935,493,134	11.78
100,000	150,000	563,455,833	4,805,762,142	11.75
150,000	250,000	525,431,138	4,475,327,705	11.73
250,000	400,000	337,695,172	2,872,741,202	11.73
400,000		1,483,417,627	12,683,545,229	11.57
Total		$3,890,987,918	33,116,473,573	
Weighted Average				$11.75

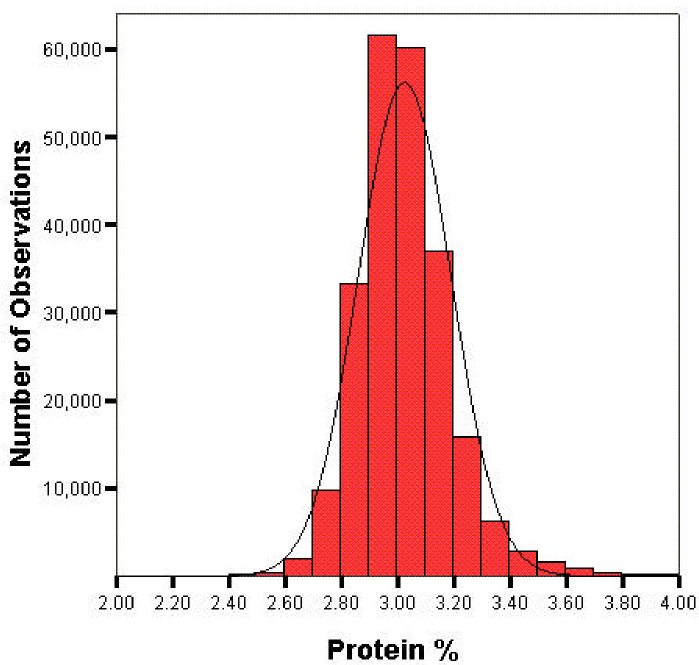
* Total value of pounds of butterfat, protein, and other solids, adjusted for SCC.

Figure A-1
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE BUTTERFAT LEVELS, 2003



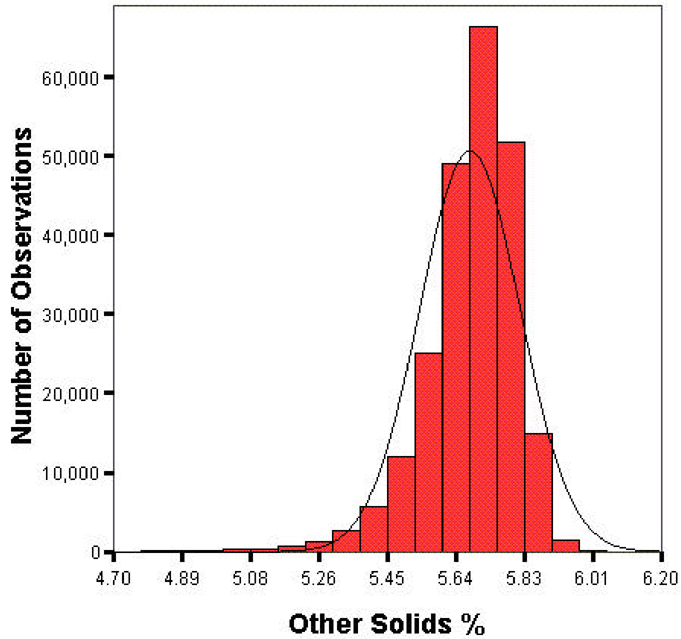
Skewness statistic: 0.79

Figure A-2
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE PROTEIN LEVELS, 2003



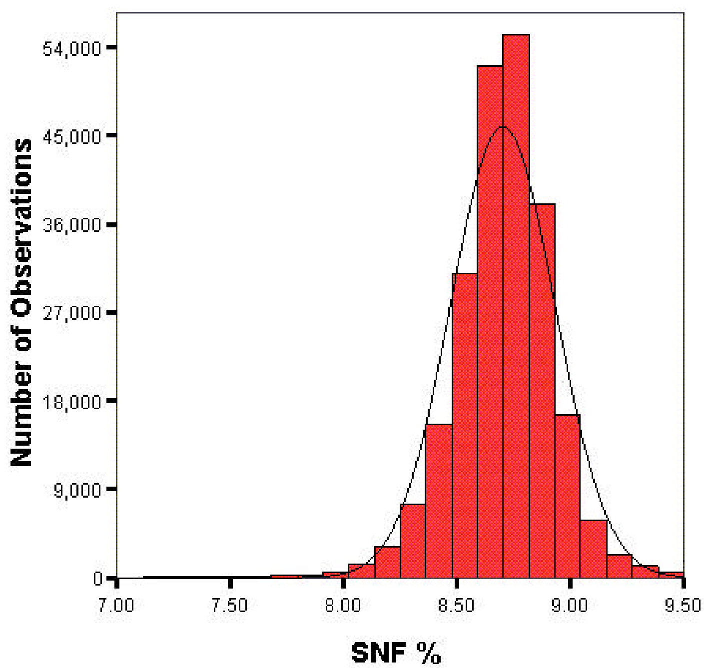
Skewness statistic: 0.87

Figure A-3
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE OTHER SOLIDS LEVELS, 2003



Skewness statistic: -2.78

Figure A-4
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOLIDS-NOT-FAT LEVELS, 2003



Skewness statistic: -0.89

Figure A-5
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOMATIC CELL COUNT, 2003

Skewness statistic: 1.41

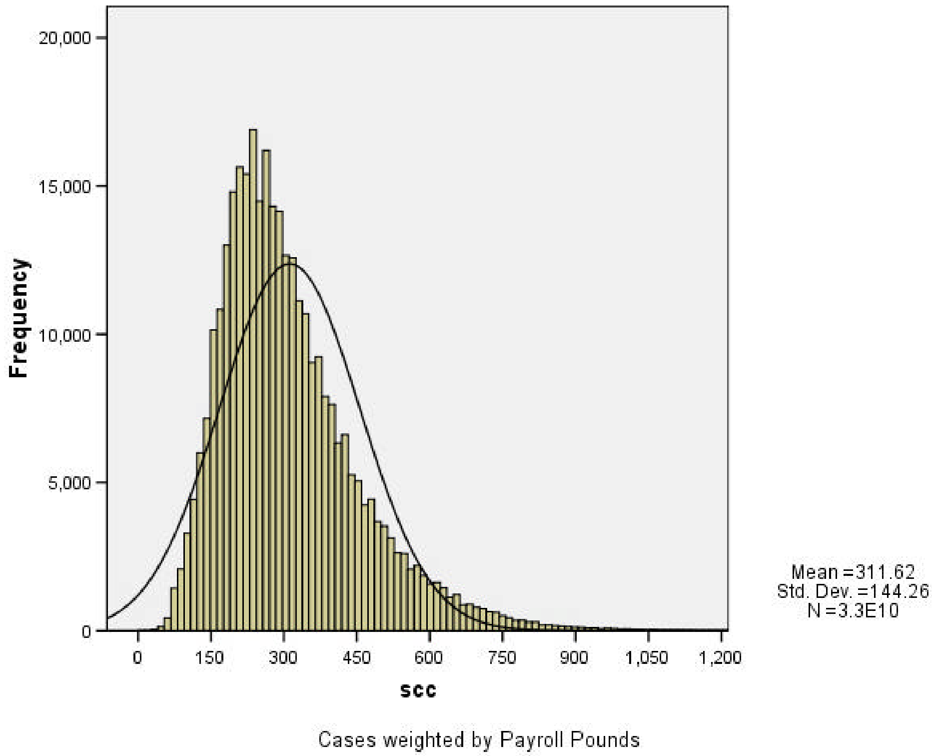


Figure A-6
WEIGHTED AVERAGE MONTHLY BUTTERFAT TESTS
2000, 2001, 2002, & 2003

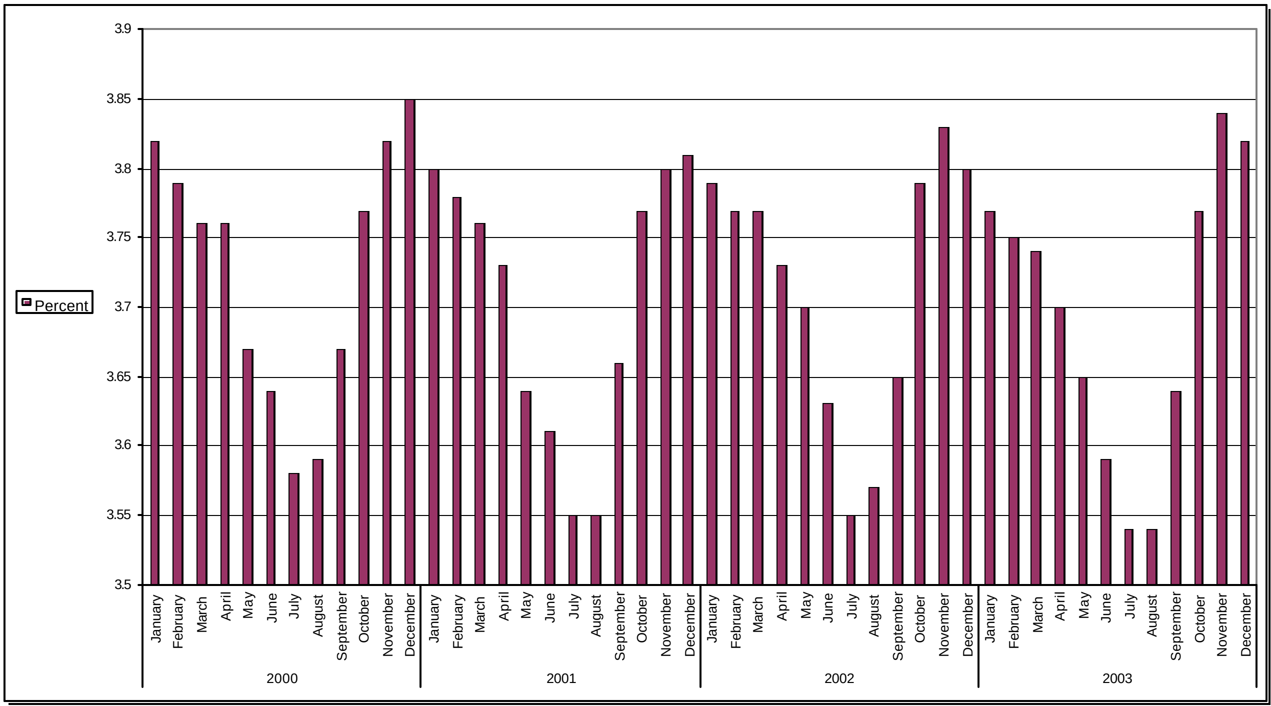


Figure A-7
WEIGHTED AVERAGE MONTHLY PROTEIN TESTS
2000, 2001, 2002, & 2003

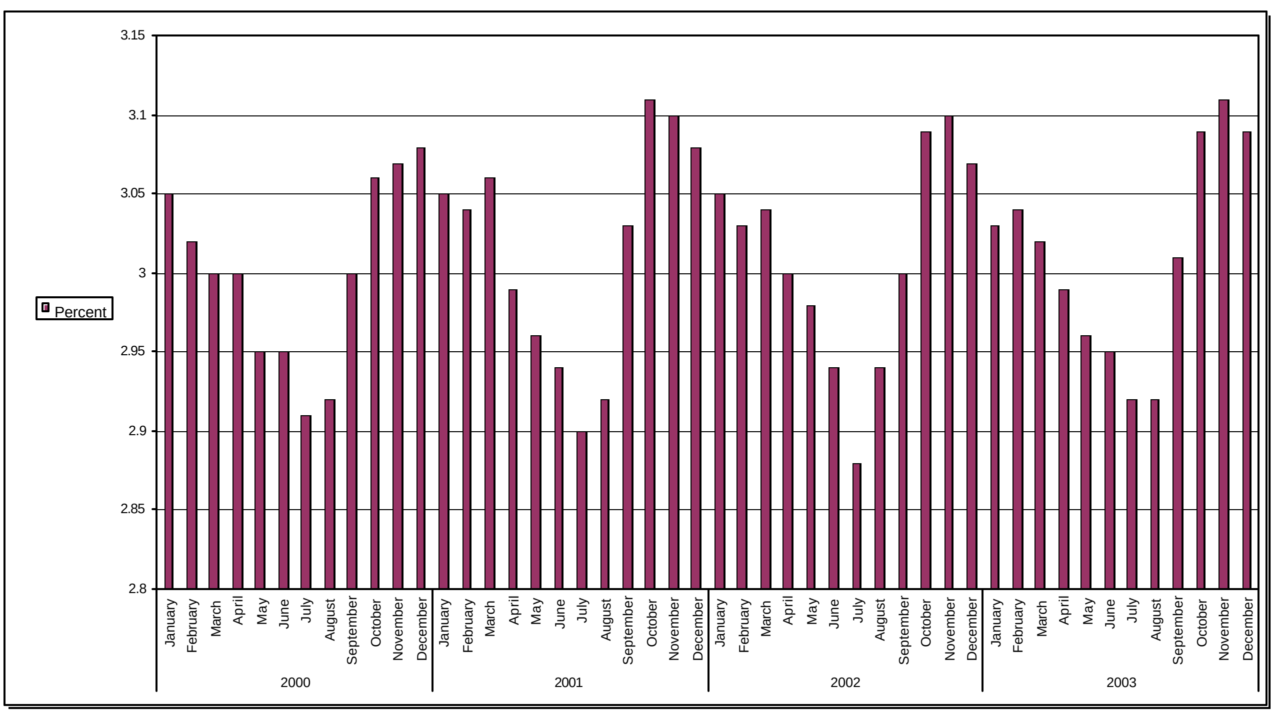


Figure A-8
WEIGHTED AVERAGE MONTHLY OTHER SOLIDS TESTS
2000, 2001, 2002, & 2003

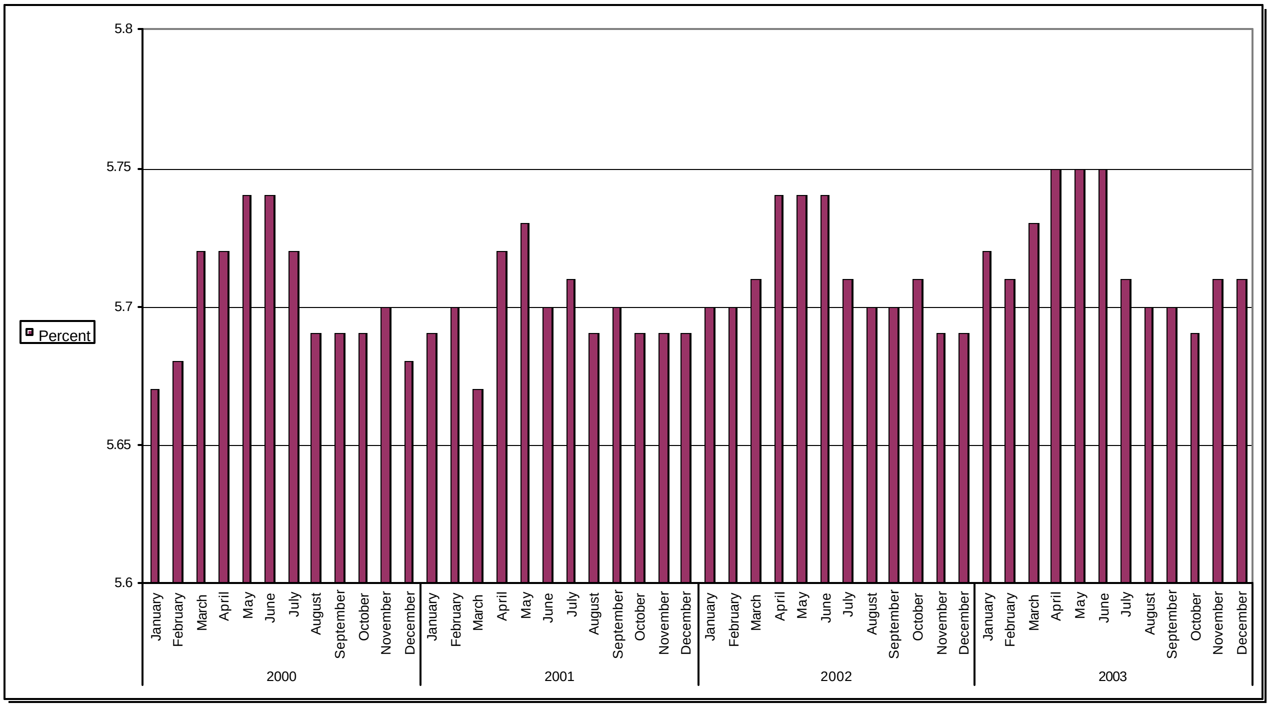


Figure A-9
WEIGHTED AVERAGE MONTHLY SOLIDS-NOT-FAT TESTS
2000, 2001, 2002, & 2003

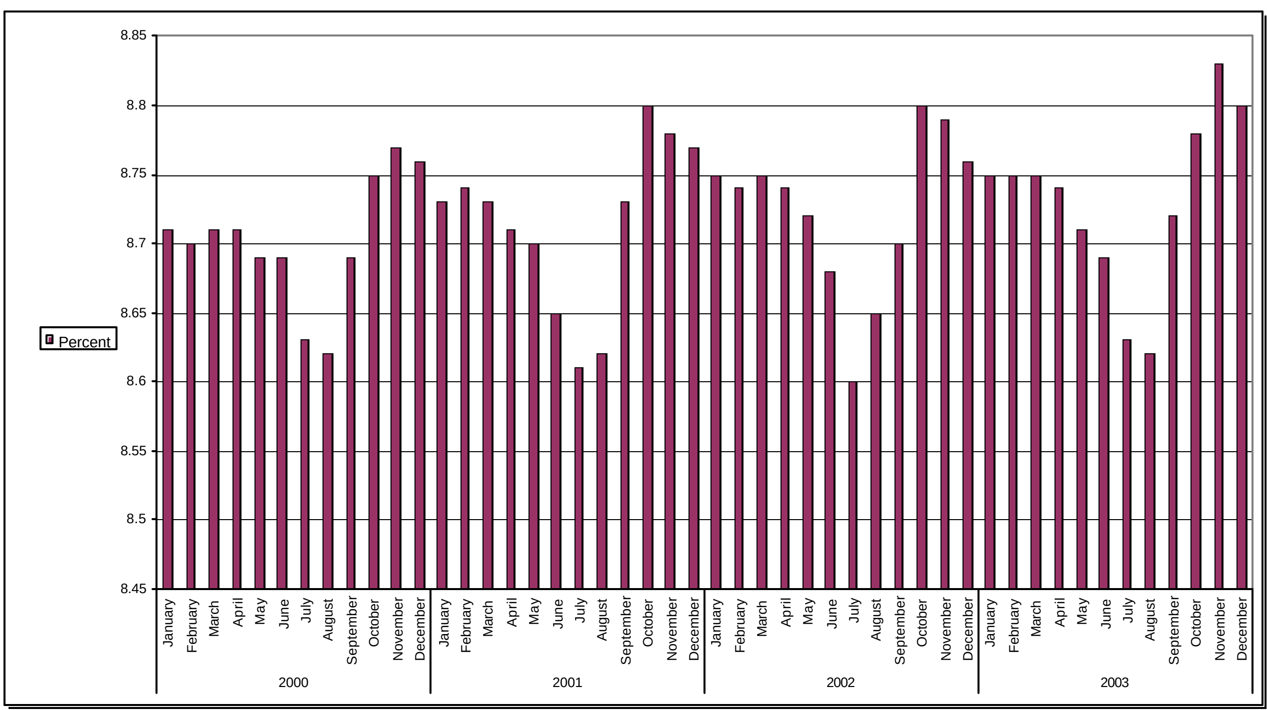


Figure A-10
WEIGHTED AVERAGE MONTHLY SOMATIC CELL COUNTS
2000, 2001, 2002, & 2003