UPPER MIDWEST MARKETING AREA

ANALYSIS OF COMPONENT LEVELS AND SOMATIC CELL COUNT IN INDIVIDUAL HERD MILK AT THE FARM LEVEL
2009

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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 2009. 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 2009 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 2009 were 3.70% butterfat, 3.04% protein, 5.73% other solids, 8.77% SNF and 265,000 SCC.

2) For 2009, weighted average butterfat levels were lowest in July, while protein and SNF levels were lowest in July and highest during the fall and winter. In contrast, other solids levels varied little during the year. Weighted average SCC were lowest in the fall and 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 2009, the range of weighted average component levels within one standard deviation of the mean was: 3.43% to 3.97% for butterfat; 2.89% to 3.19% for protein; 5.64% to 5.82% for other solids; 8.60% to 8.94% for SNF; and 135,000 to 395,000 for SCC.

5) Based on the data for 2009, the following regression equations were derived:

$$SNF = 7.37049\% + 0.35830\ (BF)$$

$$SNF = 5.56487\% + 1.03577\ (PRO)$$

$$PRO = 1.55676\% + 0.39493\ (BF)$$

6) The annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $11.77 per cwt. for the market in 2009. Protein was the most valuable component, contributing over half of the total value.

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I. INTRODUCTION

The data for this study were collected for milk marketed in 2009 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 2009 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 are 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. 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 2009, 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 2009 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 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 2009 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

2009

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.80	3.09	5.71	8.80	272
February	3.75	3.06	5.72	8.78	276
March	3.73	3.05	5.73	8.78	273
April	3.71	3.03	5.71	8.74	263
May	3.65	3.00	5.73	8.73	256
June	3.61	2.96	5.75	8.70	268
July	3.56	2.95	5.75	8.69	287
August	3.60	2.97	5.73	8.70	287
September	3.65	3.03	5.73	8.76	263
October	3.78	3.12	5.74	8.86	246
November	3.78	3.10	5.72	8.82	242
December	3.79	3.11	5.72	8.83	242
Minimum	3.56	2.95	5.71	8.69	242
Maximum	3.80	3.12	5.75	8.86	287
Annual Average	3.70	3.04	5.73	8.77	265

During the year, butterfat levels dropped from 3.80% in January to 3.56% in July, then rose to 3.79% by December. 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 0.27, 0.15 and 0.17 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 June and July and a low of 5.71% in January. The seasonal high SCC of 287,000 was reached in July and August before a low of 242,000 in November and December, a change of 45,000 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 2009, the simple average SCC (319,000) was higher than the weighted average (265,000) indicating that larger producers tended to have, on average, lower SCC than their smaller counterparts. Moreover, the median SCC level (235,000) 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]

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[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 1.564. 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

2009

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum
	- % -	- % -	- % -	- % -	- % -	- % -
Butterfat	3.70	3.81	0.27	3.67	1.01	6.57
Protein	3.04	3.06	0.15	3.02	1.57	4.63
Other Solids	5.73	5.67	0.09	5.74	3.46	9.14
SNF	8.77	8.73	0.17	8.76	5.40	12.29
SCC (1,000's)	265	319	130	235	5	2,907

The range of component levels observed in the data was fairly wide. Individual monthly average butterfat levels in the data were as low as 1.01% and as high as 6.57%; protein levels ranged from 1.57% to 4.63%; other solids levels ranged from 3.46% to 9.14%; SNF levels ranged from 5.40% to 12.29%; and SCC ranged from 5,000 to 2,907,000.

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: 3.43% to 3.97% for butterfat; 2.89% to 3.19% for protein; 5.64% to 5.82% for other solids; 8.60% to 8.94% for SNF; and 135,000 to 395,000 for SCC. Approximately three-quarters of the observed component levels and SCC in the 2009 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 2009 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 and the medians 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 2009 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 2009

Percentile	Monthly Average Pounds	Butterfat Test	Protein Test	Other Solids Test	Solids Not Fat Test	Somatic Cell Count
		- % -	- % -	- % -	- % -	- 1,000 -
1	22,878	3.91	3.08	5.59	8.67	376
2	39,682	3.87	3.07	5.63	8.70	369
3	52,817	3.85	3.06	5.65	8.71	350
4	66,100	3.82	3.05	5.67	8.72	335
5	80,918	3.80	3.05	5.69	8.74	325
6	97,963	3.78	3.05	5.70	8.74	307
7	121,462	3.76	3.04	5.71	8.75	297
8	158,302	3.75	3.04	5.72	8.76	281
9	245,207	3.72	3.04	5.73	8.77	260
10	1,062,457	3.63	3.03	5.75	8.78	234
Average	194,762	3.70	3.04	5.73	8.77	265

Monthly Average Producer Milk by Producer Size 2009

Percentile	Number of Producers	Monthly Average Pounds	Minimum Monthly Average Pounds	Maximum Monthly Average Pounds	Total Pounds	Percent of Total Pounds	Cumulative Percent of Total
1	1,644	22,878	792	32,793	451,332,057	1.17	1.17
2	1,644	39,682	32,810	46,331	782,848,526	2.04	3.21
3	1,645	52,817	46,337	59,295	1,042,610,594	2.71	5.92
4	1,644	66,100	59,296	73,200	1,304,028,029	3.39	9.32
5	1,644	80,918	73,226	88,741	1,596,347,910	4.15	13.47
6	1,645	97,963	88,748	108,351	1,933,791,023	5.03	18.50
7	1,644	121,462	108,396	136,242	2,396,209,676	6.24	24.74
8	1,645	158,302	136,262	186,589	3,124,886,664	8.13	32.87
9	1,644	245,207	186,598	335,291	4,837,449,140	12.59	45.46
10	1,644	1,062,457	335,359	11,016,283	20,960,161,486	54.54	100.00
Total or Average	16,443	194,762			38,429,665,104		

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 22,878 pounds per month had an average butterfat test of 3.91% while producers averaging 1,062,457 pounds averaged a 3.63% butterfat test. The butterfat test declined steadily from a weighted average of 3.91% for the smallest group to a weighted average of 3.75% and 3.72% for groups 8 and 9, while the group 10 producers, those averaging 1,062,457 pounds per month, had a weighted average butterfat test of 3.63%. The SCC declined steadily from an average of 376,000 for producers averaging 22,878 pounds per month to an average of 234,000 for producers averaging 1,062,457 pounds per month, a difference in the SCC of 142,000.

Protein tests also declined from the smaller producers to the larger producers but to a smaller extent than for butterfat, falling from 3.08% for producer's averaging 22,878 pounds per month to 3.03% percent for producers averaging 1,062,457 pounds of milk marketed per month.

Other solids and solids-not-fat tests steadily increased as average monthly production increased. Other solids tests increased from 5.59% to 5.75%, while solids-not-fat tests increased steadily from 8.67% to 8.78% as monthly average production increased from 22,878 pounds to 1,062,457 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 more than 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 194,762 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), as well a group of "other" states. 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, North Dakota had the highest weighted average butterfat test, protein test (along with South Dakota), other solids test (along with Iowa), solids-not-fat test, and somatic cell count. Of the states that are included in the Upper Midwest Marketing area, Michigan U.P. had the lowest weighted average SCC. Detailed state information by month for 2009 is presented in Table A-2 (see Appendix).

Table 4

Weighted Average Components Levels and Somatic Cell Count in Milk by State 2009

State	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
Illinois	3.72	3.06	5.72	8.79	277
Iowa	3.68	3.05	5.74	8.79	278
Michigan U.P.	3.58	3.03	5.69	8.72	189
Minnesota	3.71	3.05	5.73	8.78	280
North Dakota	3.77	3.11	5.74	8.85	292
South Dakota	3.73	3.11	5.73	8.84	284
Wisconsin	3.70	3.02	5.73	8.75	260
Other[8]	3.66	3.09	5.70	8.80	247
Market	3.70	3.04	5.73	8.77	265
Minimum	3.58	3.02	5.69	8.72	189
Maximum	3.77	3.11	5.74	8.85	292

IV. STATISTICAL RELATIONSHIPS AMONG MILK COMPONENTS

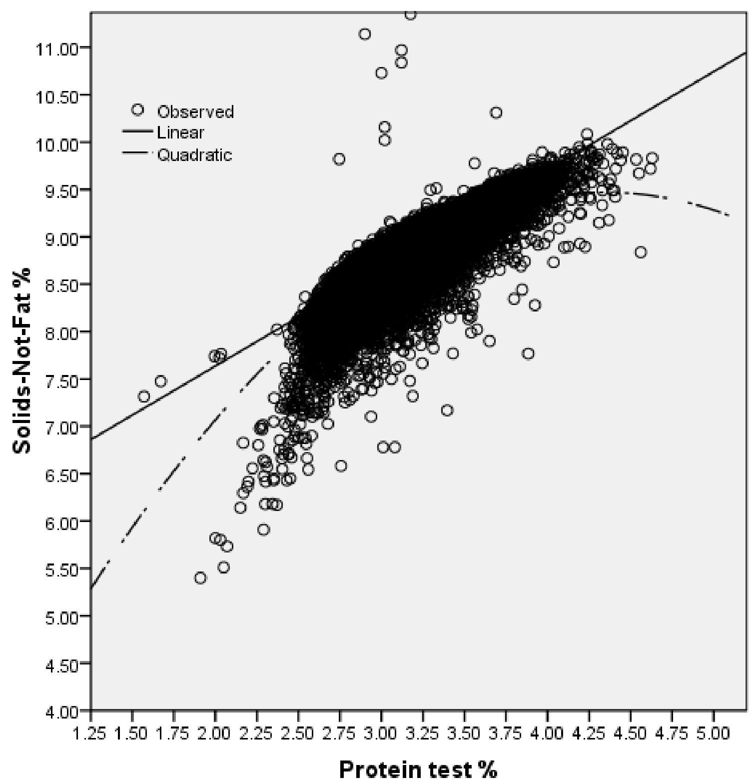
Past Upper Midwest staff papers dealing with milk component levels and the relationships between components in the milk discussed the relationships between milk components based on regression analysis using the formula for a straight line. However, if we look at a scatter plot of solids-not-fat and protein, 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

[8] Includes milk from Arkansas, Idaho, Indiana, Kansas, Louisiana, Missouri, Nebraska, Ohio, Oklahoma, Pennsylvania, and Washington.

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 2009



Regression analysis was used to estimate the linear relationship between components. Results from the 2009 data were compared with results from previous Upper Midwest Order studies (1993-2008), 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:

$$\textit{Component A} = c + b\,(\textit{Component B}) + e$$

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:

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

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 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 0.38175 from Mykrantz 1993 to 0.4640 for Halverson/Kyburz. The butterfat coefficient derived from the 2009 data was outside that range at 0.35830. 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 the months of July, September, October, and November 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 (2010 Staff Paper 10-03)	SNF = 7.37049% + 0.35830 (BF)
Upper Midwest (2010 Staff Paper 10-02)	SNF = 7.23152% + 0.39116 (BF)
Upper Midwest (2008 Staff Paper 08-01)	SNF = 7.15274% + 0.41445 (BF)
Upper Midwest (2007 Staff Paper 07-01)	SNF = 7.21470% + 0.40136 (BF)
Upper Midwest (2006 Staff Paper 06-04)	SNF = 7.25589% + 0.38394 (BF)
Upper Midwest (2006 Staff Paper 06-03)	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 2009 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 July 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 2009. 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 2009, for the linear model is:

$$\text{Solids-not-fat Test} = 5.56487 + 1.03577 * \text{Protein Test},$$

while the equation for the quadratic model is:

$$\text{Solids-not-fat Test} = 1.22581 + (3.794 * \text{Protein Test}) + (-0.437 * (\text{Protein Test})^2).$$

The R-squared for the linear model is 0.678 while the R-squared for the quadratic model is 0.695. 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 (2010 Staff Paper 10-03)	SNF = 5.56487% + 1.03577 (PRO)
Upper Midwest (2010 Staff Paper 10-02)	SNF = 5.45752% + 1.06565 (PRO)
Upper Midwest (2008 Staff Paper 08-01)	SNF = 5.47427% + 1.06208 (PRO)
Upper Midwest (2007 Staff Paper 07-01)	SNF = 5.48006% + 1.06412 (PRO)
Upper Midwest (2006 Staff Paper 06-04)	SNF = 5.61615% + 1.01655 (PRO)
Upper Midwest (2006 Staff Paper 06-03)	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 2009 data and those of Halverson/Kyburz (see Table 7). The primary observation from the equation derived for the 2009 data was that the constant of 1.55676 and the coefficient of 0.39493 for the independent variable fell within the range of coefficients previously computed

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 were statistically significant. 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 (2010 Staff Paper 10-03)	PRO = 1.55676% + 0.39493 (BF)
Upper Midwest (2010 Staff Paper 10-02)	PRO = 1.51589% + 0.40586 (BF)
Upper Midwest (2008 Staff Paper 08-01)	PRO = 1.48682% + 0.41490 (BF)
Upper Midwest (2008 Staff Paper 07-01)	PRO = 1.54359% + 0.40000 (BF)
Upper Midwest (2008 Staff Paper 06-04)	PRO = 1.51409% + 0.40387 (BF)
Upper Midwest (2006 Staff Paper 06-03)	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 2009 data. The straight line is the result of the linear model while the curved line is the result of the quadratic model. The equation for 2009, for the linear model is:

$$\textit{Protein Test} = 1.55676 + 0.39493 * \textit{Butterfat Test},$$

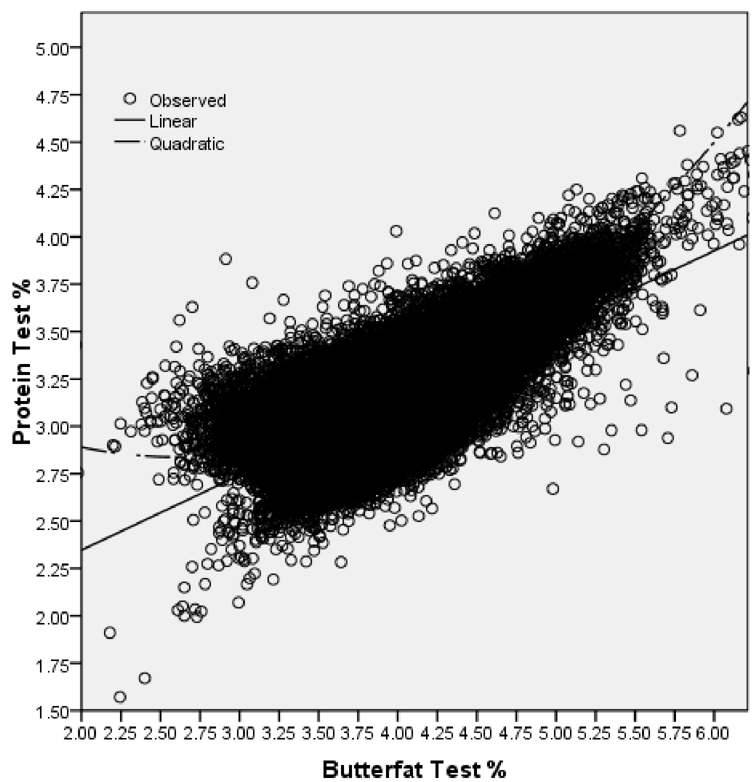
while the equation for the quadratic model is:

$$\textit{Protein Test} = 3.81280 + (-0.74642 * \textit{Butterfat Test}) + (0.14399 * (\textit{Butterfat Test})^2).$$

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 the 2009 dataset has a slightly higher adjusted R-squared of 0.512, versus 0.481 for the linear model, suggesting a better fit.

Figure 2

Scatter Plot of Protein and Butterfat Tests -- January 2009



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 0.608 suggests that a moderately strong linear relationship exists while protein and SNF appears to have a strong relationship with a coefficient of 0.824. 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.

[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 $$Y = \alpha + \beta X + \varepsilon$$

Quadratic $$Y = \alpha + \beta_1 X + \beta_2 X^2 + \varepsilon$$

Fixed Effects $$Y = \alpha + \beta_1 X + \beta_2 D_{jan} \ldots + \beta_{13} D_{dec} + \varepsilon$$

which has an equivalent representation as:

$$Y = \alpha_c + \alpha_1 D_{jan} + \ldots \alpha_{11} D_{nov} + \beta X + \varepsilon$$

Where the equivalency comes in as:

$$\alpha_1 = \alpha_c - \beta_2$$

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.

Table 8

Fixed Effects Model for 2009

$$SNFtest = \beta_1 Proteintest + \alpha_{jan} \ldots + \alpha_{\mathrm{dec}} + \varepsilon$$

Variable	Beta	Standard Error	t-stat
Protein Test	**1.062322**	**0.001647**	**644.9228**
January	5.465586	0.005213	1048.410
February	5.478415	0.005155	1062.689
March	5.489115	0.005134	1069.242
April	5.481137	0.005086	1077.661
May	5.497992	0.005065	1085.582
June	5.518708	0.004988	1106.374
July	5.506771	0.004958	1110.758
August	5.482746	0.004996	1097.491
September	5.468558	0.005110	1070.143
October	5.480646	0.005277	1038.495
November	5.460102	0.005257	1038.608
December	5.473045	0.005257	1041.031

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

Table 8 (continued)

Fixed Effects Model for 2009

$$Protein\,test = \beta_1 Butterfat\,test + \alpha_{jan} \ldots + \alpha_{dec} + \varepsilon$$

Variable	Beta	Standard Error	t-stat
Butterfat Test	**0.369054**	**0.000921**	**400.4978**
January	1.669811	0.003722	448.589
February	1.650565	0.003682	448.238
March	1.640410	0.003675	446.410
April	1.623438	0.003645	445.395
May	1.641669	0.003569	460.005
June	1.621284	0.003504	462.686
July	1.620030	0.003462	467.981
August	1.628194	0.003499	465.372
September	1.672829	0.003561	469.712
October	1.708170	0.003726	458.506
November	1.695315	0.003726	454.969
December	1.691986	0.003735	453.063

Dependent Variable: Protein Test
Linear Regression through the Origin

$$SNF\ test = \beta_1 Butterfat\,test + \alpha_{jan} \ldots + \alpha_{dec} + \varepsilon$$

Variable	Beta	Standard Error	t-stat
Butterfat Test	**0.337320**	**0.001417**	**238.0388**
January	7.453721	0.005724	1302.115
February	7.443619	0.005663	1314.481
March	7.443048	0.005651	1317.126
April	7.415312	0.005605	1322.921
May	7.446936	0.005488	1356.903
June	7.441997	0.005389	1381.056
July	7.426073	0.005324	1394.952
August	7.413001	0.005380	1377.788
September	7.450061	0.005477	1360.299
October	7.509758	0.005729	1310.794
November	7.475582	0.005730	1304.580
December	7.485484	0.005743	1303.395

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

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.

$$Y = \alpha_c + \beta_1 X_{jan} + \ldots + \beta_{12} X_{dec} + \varepsilon$$

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

Table 9

Random Effects Model for 2009

$$Protein\,test = \alpha + \beta_{\mathrm{jan}} Butterfat\ test \ldots \beta_{\mathrm{dec}} Butterfat\ test + \varepsilon$$

	Beta	Standard Error	t-stat
(Constant)	**1.661705**	**0.003581**	**470.6698**
January	0.371300	0.000926	400.7961
February	0.366272	0.000938	390.5433
March	0.363539	0.000940	386.6620
April	0.358967	0.000948	378.7245
May	0.363496	0.000969	375.2397
June	0.357974	0.000988	362.1460
July	0.357508	0.001002	356.7523
August	0.359824	0.000991	363.2071
September	0.371971	0.000972	382.7847
October	0.380947	0.000925	411.8620
November	0.377768	0.000924	408.6757
December	0.376854	0.000922	408.7752

Dependent Variable: Protein Test

Table 9 (continued)

Random Effects Model for 2009

$$SNF\ test = \alpha + \beta_{\text{jan}} Butterfat\ test \ldots \beta_{\text{dec}} Butterfat\ test + \varepsilon$$

	Beta	Standard Error	t-stat
(Constant)	**7.453546**	**0.005434**	**1371.6326**
January	0.337597	0.001426	236.7607
February	0.334891	0.001444	231.9967
March	0.334566	0.001447	231.1931
April	0.327330	0.001459	224.3709
May	0.335489	0.001491	225.0091
June	0.334257	0.001521	219.6976
July	0.329881	0.001542	231.8701
August	0.326317	0.001525	214.0016
September	0.336352	0.001496	224.8808
October	0.351430	0.001424	246.8532
November	0.342803	0.001423	240.9415
December	0.345329	0.001419	243.3642

Dependent Variable: Solids-Not-Fat Test

The F-Test

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

Table 10

F-Test Results for Monthly Data

Model	n-1	n-2	F-value	Critical Value
Solids-Not-Fat and Butterfat	11	214495	400.4	2.18
Protein and Butterfat	11	214495	1076.8	2.18
Solids-Not-Fat and Protein	11	214495	371.6	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.

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.

Table 11

Lagrange Multiplier Tests for the Random Effects Model

Model	Months	States
Solids-Not-Fat and Butterfat	10136	20471
Protein and Butterfat	1103	3522
Somatic Cell Count and Butterfat	694	2627

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 and state data the results are:

Table 12
Correlation Decomposition May 2009

	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	1.00200	0.94228	1.00120	0.87616	0.94211	0.99149
b^b	0.39514	0.59031	0.00010	0.36844	0.50954	0.00012
b^w	0.80101	0.43469	0.00889	0.57760	1.74980	-0.00341
b^t	0.39434	0.58133	0.00009	0.39434	0.58133	0.00009

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 2009. 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 2009, the cumulative value of butterfat, protein, other solids and an adjustment for SCC averaged $11.77 per cwt. for the market. The value of each component comprised by the $11.77 per cwt. price was $4.66 for butterfat, $6.73 for protein, and $0.33 for other solids. The SCC adjustment for the year amounted to about $0.06 per cwt.

Categorized by size range of delivery, average values of producer milk ranged from a low of $11.71 per cwt. for monthly producer milk deliveries greater than 400,000 pounds to a high of $12.36 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, per hundredweight, 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. 2005 - 2009 WEIGHTED AVERAGE COMPONENT TESTS

Weighted average component data for the past five years, 2005, 2006, 2007, 2008 and 2009 are shown in Table 13. Over these five years the yearly average tests have changed very little. Yearly average butterfat tests were 3.69 percent, 3.71 percent, 3.70 percent, 3.71 percent, and 3.70 percent for 2005, 2006, 2007, 2008, and 2009 respectively. Yearly average protein and other solids tests varied even less than the butterfat test between the five years. Yearly weighted average somatic cell counts also did not change much over the five-year period, decreasing from 285,000 in 2005 to 265,000 in 2009.

Graphs (see Appendix Figures A-6 through A-10) show the monthly weighted average component tests for 2005, 2006, 2007, 2008, and 2009. 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 2005 through 2009 would indicate that these two factors have 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

2005

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.78	3.08	5.69	8.77	266
February	3.74	3.04	5.72	8.76	270
March	3.73	3.03	5.73	8.76	268
April	3.69	2.99	5.74	8.74	275
May	3.66	2.98	5.74	8.72	276
June	3.57	2.92	5.76	8.69	295
July	3.53	2.89	5.76	8.65	322
August	3.55	2.94	5.72	8.66	321
September	3.63	3.02	5.70	8.72	305
October	3.74	3.11	5.69	8.79	287
November	3.83	3.13	5.70	8.83	270
December	3.85	3.12	5.67	8.80	271
Annual Average	3.69	3.02	5.72	8.74	285

Table 13 (continued)

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

2006

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.77	3.06	5.72	8.78	275
February	3.77	3.07	5.73	8.80	272
March	3.75	3.05	5.73	8.78	272
April	3.71	3.02	5.72	8.74	274
May	3.67	3.00	5.74	8.74	270
June	3.60	2.96	5.73	8.69	286
July	3.57	2.92	5.74	8.65	301
August	3.56	2.95	5.73	8.68	326
September	3.70	3.06	5.72	8.78	298
October	3.81	3.12	5.72	8.85	267
November	3.83	3.12	5.72	8.84	259
December	3.81	3.10	5.70	8.80	264
Annual Average	3.71	3.03	5.73	8.76	280

2007

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.77	3.07	5.73	8.80	268
February	3.80	3.09	5.70	8.78	285
March	3.75	3.05	5.69	8.74	293
April	3.71	3.02	5.72	8.75	286
May	3.64	2.98	5.72	8.70	280
June	3.58	2.94	5.72	8.66	295
July	3.55	2.92	5.73	8.65	306
August	3.56	2.95	5.72	8.66	329
September	3.65	3.02	5.73	8.75	311
October	3.74	3.08	5.71	8.79	288
November	3.82	3.14	5.70	8.85	260
December	3.84	3.13	5.70	8.84	255
Annual Average	3.70	3.03	5.71	8.75	288

Table 13 (continued)

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

2008

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.81	3.10	5.69	8.79	259
February	3.79	3.10	5.70	8.80	281
March	3.77	3.07	5.70	8.77	287
April	3.72	3.02	5.70	8.72	281
May	3.66	3.01	5.70	8.71	284
June	3.60	2.97	5.73	8.70	299
July	3.57	2.93	5.72	8.65	313
August	3.59	2.95	5.72	8.67	314
September	3.67	3.02	5.72	8.74	293
October	3.77	3.10	5.73	8.82	270
November	3.81	3.12	5.71	8.83	252
December	3.83	3.12	5.71	8.83	260
Annual Average	3.71	3.04	5.71	8.75	283

2009

Month	Butterfat	Protein	Other Solids	Solids-Not-Fat	Somatic Cell Count
	- % -	- % -	- % -	- % -	- 1,000 -
January	3.80	3.09	5.71	8.80	272
February	3.75	3.06	5.72	8.78	276
March	3.73	3.05	5.73	8.78	273
April	3.71	3.03	5.71	8.74	263
May	3.65	3.00	5.73	8.73	256
June	3.61	2.96	5.75	8.70	268
July	3.56	2.95	5.75	8.69	287
August	3.60	2.97	5.73	8.70	287
September	3.65	3.03	5.73	8.76	263
October	3.78	3.12	5.74	8.86	246
November	3.78	3.10	5.72	8.82	242
December	3.79	3.11	5.72	8.83	242
Annual Average	3.70	3.04	5.73	8.77	265

VII. SUMMARY

This staff paper analyzes milk components and SCC in producer milk associated with the Upper Midwest Order during 2009. 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 2009 were: 3.70% butterfat, 3.04% protein, 5.73% other solids, 8.77% SNF and 265,000 SCC. The weighted average butterfat level was lowest in July, while 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 June and July and lowest in January and April and exhibited less variation during the year relative to the three other components. Weighted average SCC was lowest in the fall and winter and highest in July and August. Approximately three-quarters of monthly average component levels ranged from: 3.43% to 3.97% for butterfat; 2.89% to 3.19% for protein; 5.64% to 5.82% for other solids; 8.60% to 8.94% for SNF; and 135,000 to 395,000 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 194,762 pounds, however over 80 percent of the producers had average marketings below the market average.

Based on the data for 2009, the following regression equations were derived:

$$SNF = 7.37049\% + 0.35830\,(BF)$$
$$SNF = 5.56487\% + 1.03577\,(PRO)$$
$$PRO = 1.55676\% + 0.39493\,(BF)$$

Under MCP, the annual weighted average value of butterfat, protein, and other solids, adjusted for SCC, was $11.77 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

2009

Butterfat

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Weighted Median - % -	Minimum - % -	Maximum - % -	Number of Observations
January	3.80	3.91	0.28	3.78	1.44	6.51	17,783
February	3.75	3.87	0.27	3.73	1.01	6.30	17,703
March	3.73	3.86	0.27	3.71	2.31	6.30	17,674
April	3.71	3.83	0.26	3.68	1.96	6.30	17,916
May	3.65	3.74	0.25	3.62	2.21	6.30	18,108
June	3.61	3.67	0.23	3.59	1.33	6.36	18,057
July	3.56	3.62	0.23	3.55	1.46	5.29	17,937
August	3.60	3.66	0.23	3.59	1.39	5.71	17,950
September	3.65	3.73	0.25	3.63	1.28	5.73	17,889
October	3.78	3.92	0.29	3.74	1.03	6.39	17,874
November	3.78	3.92	0.30	3.75	1.05	6.39	17,823
December	3.79	3.93	0.30	3.76	1.12	6.57	17,783
Total	3.70	3.81	0.27	3.67	1.01	6.57	214,497

Protein

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Weighted Median - % -	Minimum - % -	Maximum - % -	Number of Observations
January	3.09	3.11	0.14	3.08	2.19	4.45	17,783
February	3.06	3.08	0.14	3.04	2.07	4.37	17,703
March	3.05	3.07	0.13	3.03	2.29	4.55	17,674
April	3.03	3.04	0.13	3.01	1.57	4.26	17,916
May	3.00	3.02	0.13	2.99	2.02	4.28	18,108
June	2.96	2.98	0.12	2.95	1.67	4.39	18,057
July	2.95	2.96	0.12	2.94	2.17	4.15	17,937
August	2.97	2.98	0.12	2.96	2.27	3.93	17,950
September	3.03	3.05	0.13	3.02	2.15	3.99	17,889
October	3.12	3.15	0.14	3.10	2.00	4.22	17,874
November	3.10	3.14	0.15	3.08	2.05	4.63	17,823
December	3.11	3.14	0.15	3.09	1.91	4.62	17,783
Total	3.04	3.06	0.15	3.02	1.57	4.63	214,497

Table A-1 (continued)

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

2009

Other Solids

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Weighted Median - % -	Minimum - % -	Maximum - % -	Number of Observations
January	5.71	5.66	0.08	5.72	3.88	5.99	17,783
February	5.72	5.67	0.09	5.73	3.66	6.20	17,703
March	5.73	5.68	0.09	5.74	3.70	9.14	17,674
April	5.71	5.67	0.08	5.72	3.62	8.18	17,916
May	5.73	5.69	0.08	5.74	3.88	6.11	18,108
June	5.75	5.70	0.08	5.76	4.08	6.02	18,057
July	5.75	5.69	0.09	5.76	4.51	5.99	17,937
August	5.73	5.67	0.09	5.74	4.15	7.14	17,950
September	5.73	5.66	0.09	5.74	3.99	6.00	17,889
October	5.74	5.68	0.11	5.75	3.82	9.07	17,874
November	5.72	5.66	0.09	5.73	3.46	6.62	17,823
December	5.72	5.67	0.08	5.73	3.49	6.18	17,783
Total	5.73	5.67	0.09	5.74	3.46	9.14	214,497

Solids-Not-Fat

Month	Weighted Average - % -	Simple Average - % -	Weighted Standard Deviation - % -	Weighted Median - % -	Minimum - % -	Maximum - % -	Number of Observations
January	8.80	8.77	0.17	8.80	6.36	9.98	17,783
February	8.78	8.75	0.17	8.78	5.73	9.77	17,703
March	8.78	8.75	0.17	8.78	6.17	12.04	17,674
April	8.74	8.71	0.16	8.74	5.91	11.35	17,916
May	8.73	8.71	0.16	8.73	6.18	9.90	18,108
June	8.70	8.68	0.16	8.71	6.43	9.93	18,057
July	8.69	8.65	0.16	8.70	6.80	9.77	17,937
August	8.70	8.65	0.16	8.71	6.55	10.16	17,950
September	8.76	8.71	0.16	8.76	6.14	9.67	17,889
October	8.86	8.83	0.18	8.85	5.82	12.29	17,874
November	8.82	8.80	0.17	8.82	5.51	10.31	17,823
December	8.83	8.81	0.17	8.83	5.40	10.08	17,783
For the Year	8.77	8.73	0.17	8.76	5.40	12.29	214,497

Table A-1 (continued)

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

2009

Somatic Cell Count

Month	Weighted Average	Simple Average	Weighted Standard Deviation	Weighted Median	Minimum	Maximum	Number of Observations
	---------- (1,000) ----------						
January	272	327	140	239	12	2,047	17,783
February	276	334	145	242	11	2,907	17,703
March	273	334	139	242	20	2,157	17,674
April	263	320	131	235	15	1,618	17,916
May	256	306	124	227	19	1,835	18,108
June	268	317	128	239	16	1,692	18,057
July	287	339	134	258	13	1,804	17,937
August	287	342	134	255	11	1,901	17,950
September	263	313	121	237	9	1,603	17,889
October	246	299	116	220	7	2,401	17,874
November	242	299	117	215	10	1,979	17,823
December	242	299	119	215	5	1,794	17,783
For the Year	265	319	130	235	5	2,907	214,497

Table A-2

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2009

Butterfat

	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.86	3.78	3.71	3.81	3.88	3.82	3.80	3.75	3.80
February	3.80	3.71	3.63	3.76	3.84	3.78	3.76	3.71	3.75
March	3.76	3.69	3.60	3.74	3.84	3.76	3.74	3.67	3.73
April	3.73	3.68	3.57	3.71	3.80	3.73	3.72	3.62	3.71
May	3.64	3.61	3.52	3.65	3.68	3.66	3.66	3.60	3.65
June	3.61	3.57	3.51	3.60	3.63	3.62	3.62	3.58	3.61
July	3.55	3.53	3.48	3.58	3.60	3.61	3.57	3.52	3.56
August	3.61	3.61	3.50	3.61	3.64	3.65	3.60	3.53	3.60
September	3.69	3.65	3.53	3.66	3.69	3.68	3.66	3.63	3.65
October	3.83	3.77	3.60	3.79	3.86	3.80	3.78	3.76	3.78
November	3.81	3.78	3.64	3.81	3.87	3.84	3.76	3.76	3.78
December	3.81	3.79	3.67	3.82	3.91	3.84	3.77	3.84	3.79
Total	3.72	3.68	3.58	3.71	3.77	3.73	3.70	3.66	3.70

Protein

	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	3.14	3.11	3.11	3.10	3.16	3.16	3.08	3.13	3.09
February	3.09	3.07	3.08	3.07	3.15	3.14	3.04	3.10	3.06
March	3.07	3.06	3.02	3.07	3.16	3.13	3.03	3.08	3.05
April	3.05	3.04	3.01	3.04	3.12	3.10	3.01	3.06	3.03
May	3.03	3.01	2.97	3.02	3.07	3.07	2.99	3.05	3.00
June	2.96	2.96	2.94	2.97	3.03	3.04	2.94	2.99	2.96
July	2.96	2.95	2.94	2.96	3.01	3.01	2.93	2.99	2.95
August	2.99	3.00	2.96	3.00	3.05	3.05	2.95	3.02	2.97
September	3.06	3.06	3.04	3.03	3.08	3.09	3.01	3.11	3.03
October	3.14	3.15	3.10	3.12	3.17	3.18	3.10	3.20	3.12
November	3.13	3.12	3.08	3.10	3.17	3.17	3.09	3.18	3.10
December	3.13	3.13	3.11	3.11	3.18	3.19	3.09	3.19	3.11
Total	3.06	3.05	3.03	3.05	3.11	3.11	3.02	3.09	3.04

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2009

Other Solids

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

Solids-Not-Fat

	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	8.85	8.84	8.80	8.79	8.84	8.86	8.80	8.84	8.80
February	8.82	8.81	8.76	8.79	8.87	8.86	8.77	8.80	8.78
March	8.82	8.82	8.70	8.79	8.89	8.86	8.76	8.79	8.78
April	8.79	8.78	8.69	8.74	8.81	8.81	8.73	8.77	8.74
May	8.77	8.77	8.66	8.74	8.79	8.79	8.72	8.76	8.73
June	8.70	8.71	8.64	8.73	8.81	8.80	8.69	8.69	8.70
July	8.68	8.70	8.64	8.72	8.80	8.78	8.68	8.69	8.69
August	8.71	8.73	8.64	8.73	8.81	8.79	8.69	8.71	8.70
September	8.77	8.78	8.74	8.77	8.85	8.84	8.74	8.81	8.76
October	8.85	8.88	8.80	8.86	8.93	8.94	8.84	8.90	8.86
November	8.83	8.85	8.77	8.82	8.91	8.89	8.81	8.88	8.82
December	8.84	8.85	8.82	8.84	8.92	8.91	8.82	8.90	8.83
Total	8.79	8.79	8.72	8.78	8.85	8.84	8.75	8.80	8.77

Table A-2 (Continued)

WEIGHTED AVERAGE COMPONENT LEVELS AND SOMATIC CELL COUNT BY STATE

2009

Somatic Cell Counts

	Illinois	Iowa	Michigan U.P.	Minnesota	N. Dakota	S. Dakota	Wisconsin	All Other States	Market
	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -	- % -
January	294	297	200	286	315	297	265	254	272
February	295	301	195	294	317	297	270	243	276
March	283	295	186	289	312	294	269	236	273
April	268	279	179	281	322	284	258	229	263
May	270	272	183	269	305	267	253	231	256
June	279	285	189	281	297	282	263	272	268
July	300	311	203	304	313	314	279	292	287
August	294	297	204	303	297	308	281	279	287
September	281	272	192	281	271	286	258	253	263
October	257	251	177	262	256	262	243	228	246
November	253	246	175	257	244	257	240	220	242
December	262	245	179	253	258	262	240	223	242
Total	277	278	189	280	292	284	260	247	265

Table A-3

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2009

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)	7.3704921	0.0051130	1441.5087	0.250
Butterfat (b)	0.3582983	0.0013391	267.5716	
SNF = c + b(BF) + m(February) + . . . + m(December)				
Constant (c)	7.4537	0.0057	1302.115	0.265
Butterfat (b)	0.3373	0.0014	238.039	
February	-0.010	0.002	-5.048	
March	-0.011	0.002	-5.330	
April	-0.038	0.002	-19.224	
May	-0.007	0.002	-3.387	
June	-0.012	0.002	-5.804	
July	-0.028	0.002	-13.580	
August	-0.041	0.002	-20.114	
September	-0.004	0.002	-1.820	
October	0.056	0.002	28.083	
November	0.022	0.002	10.948	
December	0.032	0.002	15.897	

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)	5.5648724	0.0047184	1179.4016	0.678
Protein (b)	1.0357728	0.0015395	672.7862	
SNF = c + b(PRO) + m(February) + . . . + m(December)				
Constant (c)	5.4656	0.0052	1048.410	0.684
Protein (b)	1.0623	0.0016	644.923	
February	0.013	0.001	9.769	
March	0.024	0.001	17.894	
April	0.016	0.001	11.833	
May	0.032	0.001	24.681	
June	0.053	0.001	40.091	
July	0.041	0.001	30.898	
August	0.017	0.001	12.944	
September	0.003	0.001	2.264	
October	0.015	0.001	11.493	
November	-0.005	0.001	-4.186	
December	0.007	0.001	5.689	

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2009

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)	1.5567581	0.0033839	460.0454	0.481
Butterfat (b)	0.3949253	0.0008862	445.6246	
PRO = c + b(BF) + m(February) + . . . + m(December)				
Constant (c)	1.6698	0.0037	448.589	0.508
Butterfat (b)	0.3691	0.0009	400.498	
February	-0.019	0.001	-14.789	
March	-0.029	0.001	-22.578	
April	-0.046	0.001	-35.693	
May	-0.028	0.001	-21.601	
June	-0.049	0.001	-36.945	
July	-0.050	0.001	-37.601	
August	-0.042	0.001	-31.613	
September	0.003	0.001	2.308	
October	0.038	0.001	29.562	
November	0.026	0.001	19.642	
December	0.022	0.001	17.068	

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2009

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	5.482828	1.056786	0.005294	0.691472	0.124851
February	5.446567	1.072668	0.005736	0.663944	0.128458
March	5.432596	1.080762	0.005897	0.655233	0.127952
April	5.255541	1.136618	0.005721	0.687780	0.118999
May	5.368138	1.105268	0.005275	0.708021	0.107662
June	5.340923	1.122055	0.005482	0.698800	0.106537
July	5.196743	1.167161	0.005925	0.683871	0.111202
August	5.200383	1.157052	0.006290	0.653373	0.120168
September	5.460486	1.064968	0.006070	0.632481	0.123413
October	5.776971	0.968382	0.006456	0.557316	0.149952
November	5.763171	0.965855	0.005321	0.648974	0.129339
December	5.721812	0.983140	0.004971	0.687500	0.122745

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

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

Month	**c** Constant	$\mathbf{b_1}$ Protein Coefficient	Standard Error of $\mathbf{b_1}$	$\mathbf{b_2}$ Protein Coefficient	Standard Error of $\mathbf{b_2}$	R-squared (Adjusted)	Standard Error
January	0.197712	4.348592	0.084356	-0.510432	0.013057	0.715877	0.119811
February	-0.302098	4.707664	0.096110	-0.572476	0.015111	0.689131	0.123551
March	-0.200575	4.665504	0.104528	-0.568321	0.016547	0.676789	0.123887
April	0.218931	4.396473	0.097527	-0.525929	0.015709	0.706149	0.115445
May	0.591671	4.192091	0.100059	-0.497193	0.016095	0.722624	0.104935
June	1.256338	3.804688	0.101813	-0.439195	0.016645	0.709967	0.104543
July	-0.768850	5.113635	0.119119	-0.650899	0.019624	0.702127	0.107943
August	-1.777106	5.738892	0.131473	-0.750104	0.021501	0.675369	0.116293
September	-0.719063	5.012161	0.119564	-0.628326	0.019009	0.653619	0.119811
October	0.910877	3.958257	0.118000	-0.457412	0.018026	0.572687	0.147326
November	1.757697	3.427491	0.089360	-0.376460	0.013643	0.663340	0.126665
December	1.653060	3.477596	0.077308	-0.380439	0.011767	0.704833	0.119292

Table A-3 (continued)

RELATIONSHIPS BETWEEN VARIOUS MILK COMPONENTS

2009

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	1.548395	0.400070	0.003129	0.478943	0.127671
February	1.594420	0.383565	0.003272	0.437077	0.126296
March	1.660638	0.363814	0.003326	0.403655	0.126040
April	1.730584	0.341069	0.003379	0.362516	0.124069
May	1.811705	0.323647	0.003408	0.332424	0.123935
June	1.716385	0.343152	0.003385	0.362640	0.115460
July	1.695886	0.348117	0.003388	0.370537	0.111180
August	1.730465	0.341148	0.003446	0.353160	0.114680
September	1.706664	0.359994	0.003305	0.395806	0.117875
October	1.639702	0.386525	0.002935	0.492519	0.123774
November	1.584868	0.397235	0.002865	0.518882	0.126297
December	1.613645	0.388997	0.002837	0.513975	0.129103

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	3.793894	-0.698654	0.033341	0.133325	0.004029	0.509145	0.123916
February	4.171723	-0.903496	0.036496	0.159589	0.004508	0.474265	0.122053
March	4.365196	-0.993814	0.040389	0.169276	0.005020	0.439678	0.122174
April	4.183397	-0.907703	0.041346	0.158025	0.005215	0.393560	0.121010
May	4.880434	-1.274690	0.041773	0.206910	0.005391	0.382620	0.119185
June	4.277963	-1.012799	0.039465	0.178437	0.005175	0.401979	0.111840
July	4.734138	-1.286333	0.044301	0.218666	0.005911	0.415135	0.107169
August	4.897401	-1.343435	0.043840	0.222845	0.005783	0.402559	0.110214
September	4.838476	-1.268231	0.039226	0.210365	0.005051	0.451915	0.112548
October	4.374160	-0.958289	0.031742	0.164047	0.003857	0.539140	0.117952
November	4.195101	-0.880599	0.029634	0.155009	0.003580	0.564666	0.120138
December	4.268006	-0.902071	0.028437	0.155475	0.003409	0.564849	0.122159

Table A-4

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

2009

Month	Butterfat Price	Protein Price	Other Solids Price	Somatic Cell Adjustment Rate
	($/Pound)			($/cwt. Per 1,000 SCC)
January	$1.1084	$2.3638	-$0.0304	$0.00065
February	$1.0941	$1.9139	-$0.0437	$0.00058
March	$1.1594	$2.1973	-$0.0339	$0.00063
April	$1.2049	$2.2009	-$0.0043	$0.00064
May	$1.2648	$1.7454	-$0.0336	$0.00058
June	$1.2544	$1.7283	$0.0723	$0.00057
July	$1.2438	$1.6970	$0.0949	$0.00057
August	$1.2491	$2.1009	$0.0962	$0.00063
September	$1.2226	$2.4243	$0.1018	$0.00068
October	$1.2752	$2.5584	$0.1228	$0.00071
November	$1.4656	$2.6991	$0.1524	$0.00076
December	$1.5433	$2.8751	$0.1727	$0.00080
Simple Average	$1.2571	$2.2087	$0.0612	$0.00065

Table A-5

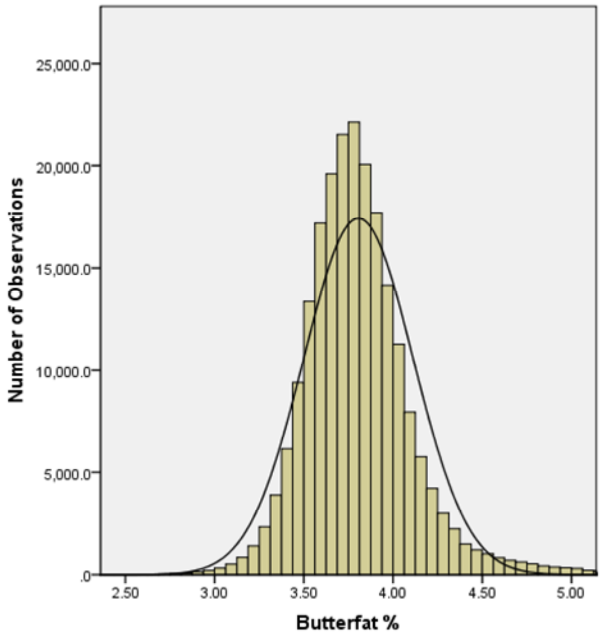
AGGREGATED COMPONENT VALUES BY SIZE RANGE OF MONTHLY PRODUCER MILK DELIVERIES

2009

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	$17,654,834.85	142,820,099	$12.36
20,000	30,000	$36,461,599.09	297,742,363	$12.25
30,000	50,000	$152,103,848.41	1,265,637,720	$12.02
50,000	70,000	$223,337,779.13	1,873,837,258	$11.92
70,000	100,000	$380,120,269.45	3,209,522,073	$11.84
100,000	150,000	$514,743,894.23	4,369,310,472	$11.78
150,000	250,000	$579,992,993.20	4,919,955,819	$11.79
250,000	400,000	$444,491,420.39	3,770,591,226	$11.79
400,000		$2,407,651,972.60	20,562,069,851	$11.71
Total		$4,756,558,611.35	40,411,486,880	
Weighted Average				$11.77

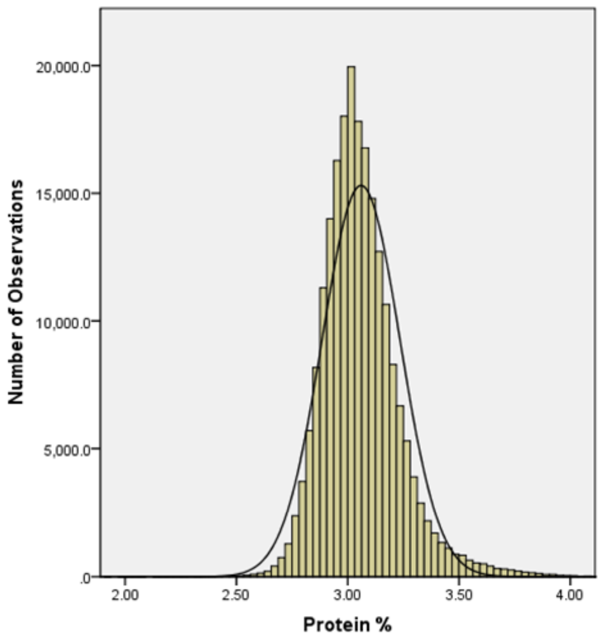
* Total value of pounds of butterfat, protein, and other solids, adjusted for SCC.

Figure A-1
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE BUTTERFAT LEVELS, 2009



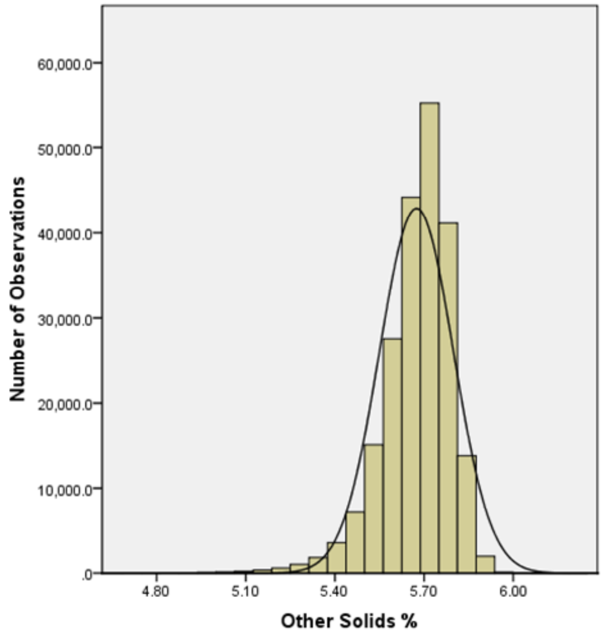
Skewness statistic: 1.094
Kurtosis statistic: 4.388

Figure A-2
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE PROTEIN LEVELS, 2009



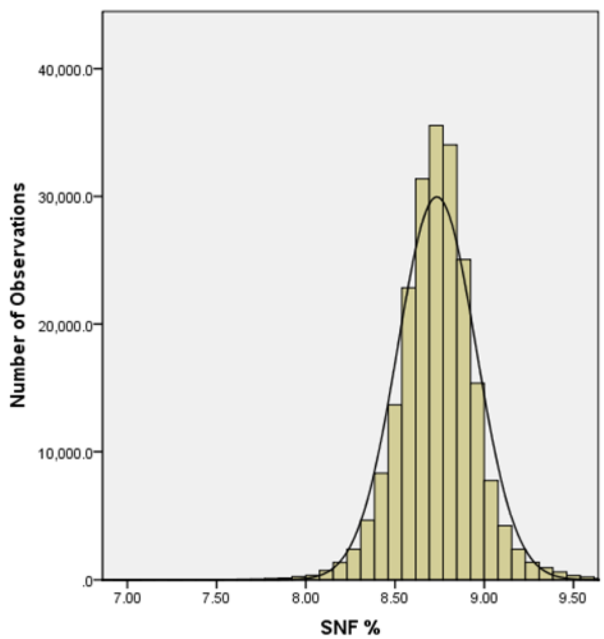
Skewness statistic: 1.136
Kurtosis statistic: 3.714

Figure A-3
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE OTHER SOLIDS LEVELS, 2009



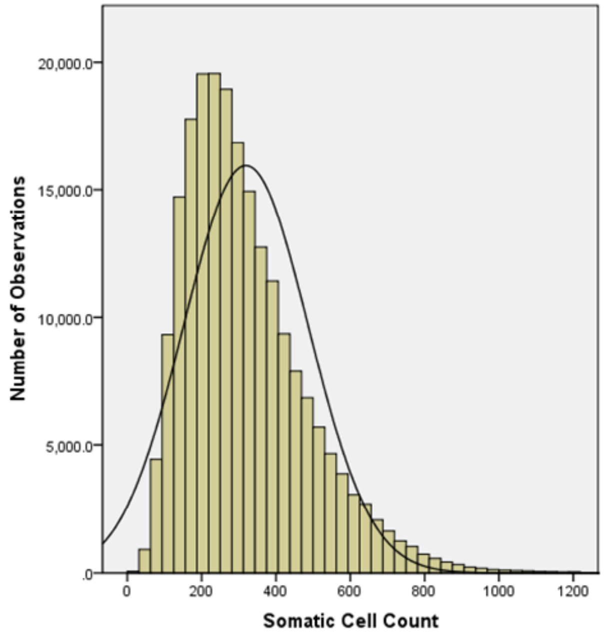
Skewness statistic: -1.127
Kurtosis statistic: 34.003

Figure A-4
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOLIDS-NOT-FAT LEVELS, 2009



Skewness statistic: -0.234
Kurtosis statistic: 7.677

Figure A-5
FREQUENCY DISTRIBUTION OF
MONTHLY AVERAGE SOMATIC CELL COUNT, 2009



Skewness statistic: 1.369
Kurtosis statistic: 4.114

Figure A-6
WEIGHTED AVERAGE MONTHLY BUTTERFAT TESTS
2005, 2006, 2007, 2008, & 2009

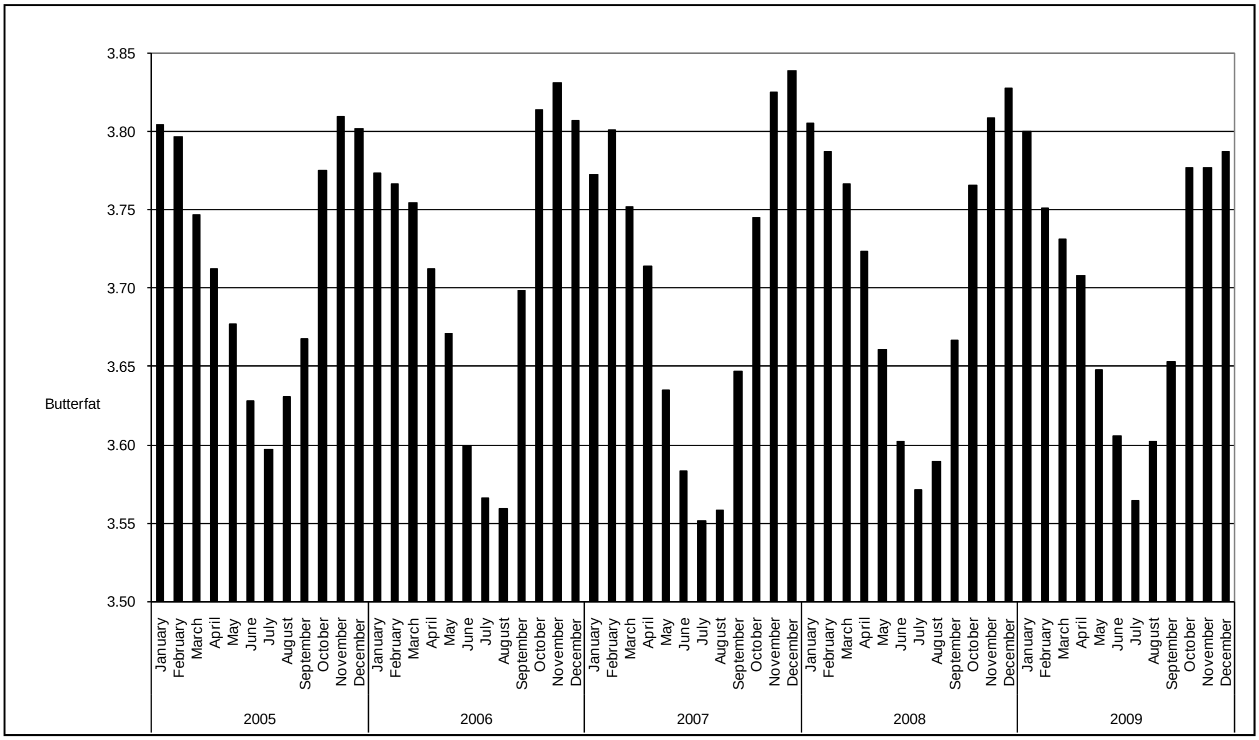


Figure A-7
WEIGHTED AVERAGE MONTHLY PROTEIN TESTS
2005, 2006, 2007, 2008, & 2009

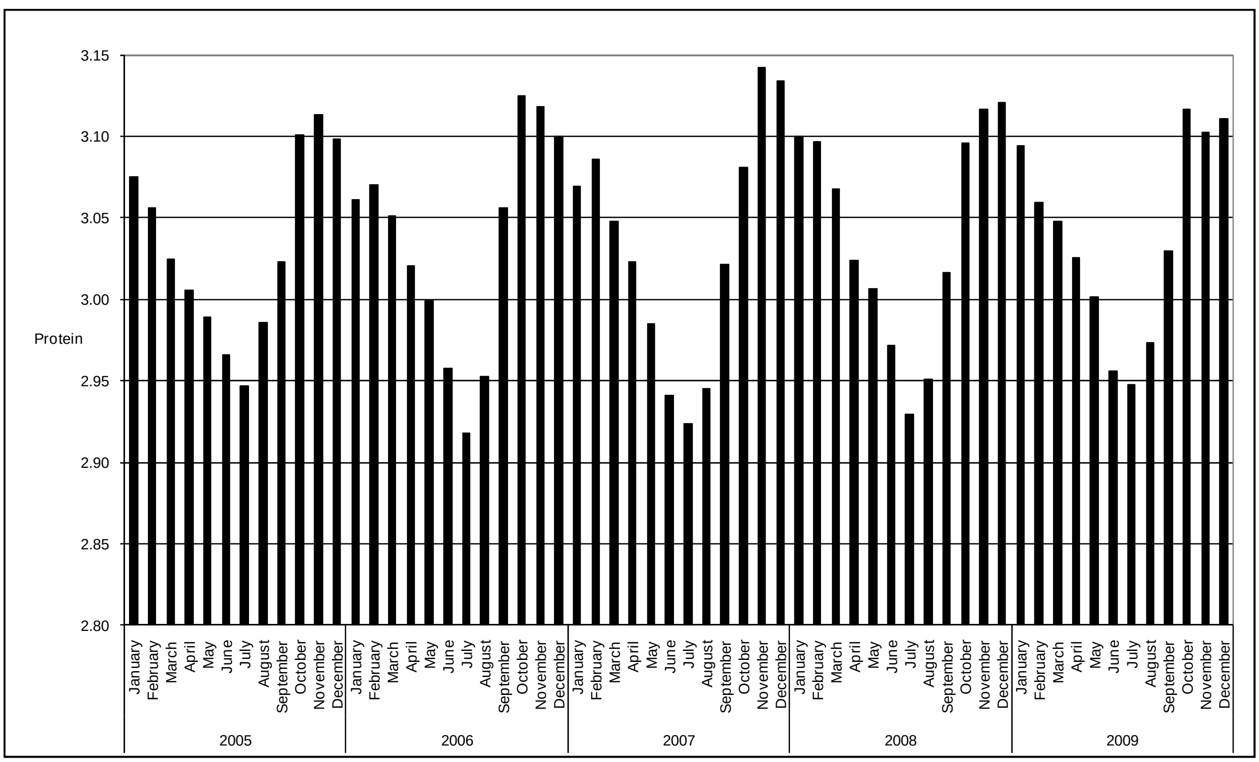


Figure A-8
WEIGHTED AVERAGE MONTHLY OTHER SOLIDS TESTS
2005, 2006, 2007, 2008, & 2009

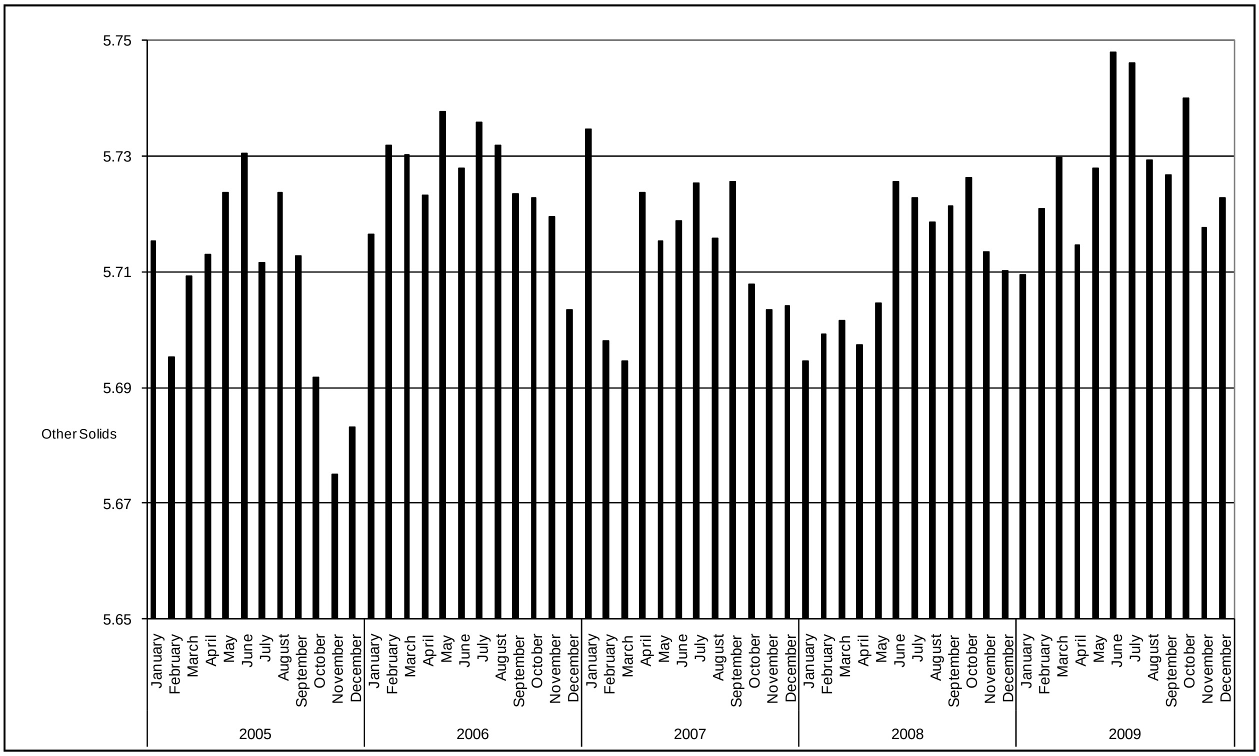


Figure A-9
WEIGHTED AVERAGE MONTHLY SOLIDS-NOT-FAT TESTS
2005, 2006, 2007, 2008, & 2009

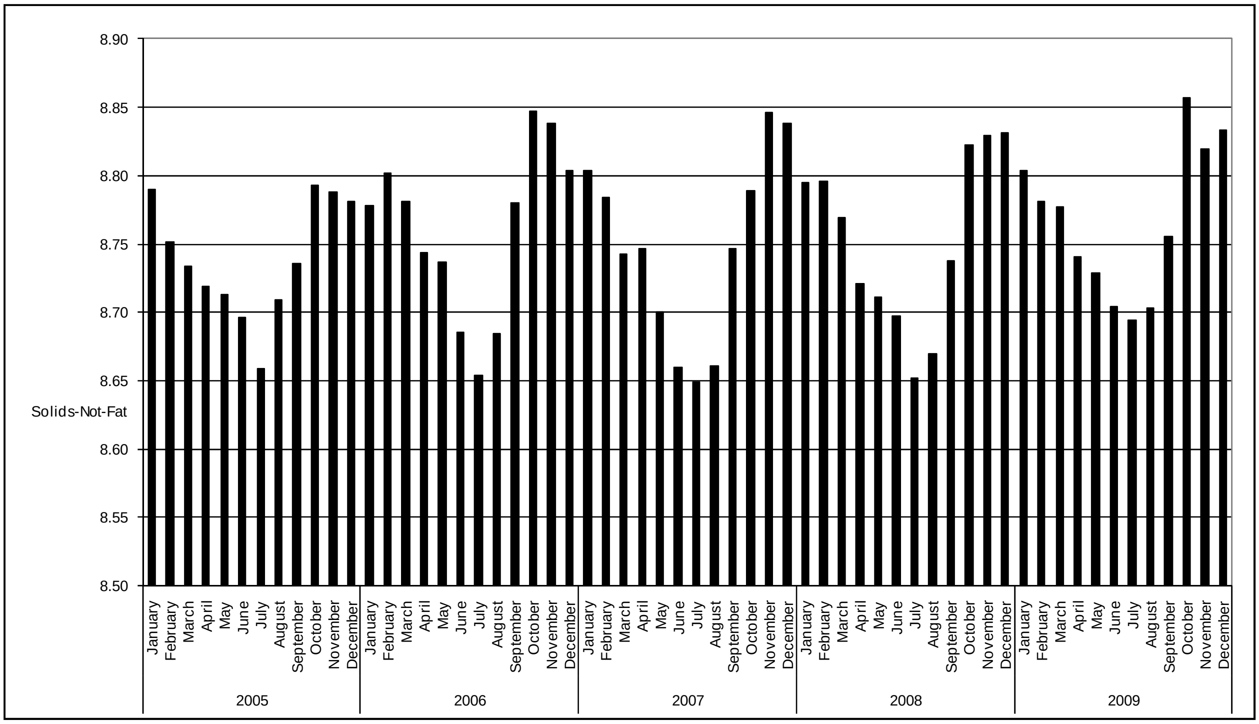


Figure A-10
WEIGHTED AVERAGE MONTHLY SOMATIC CELL COUNTS
2005, 2006, 2007, 2008, & 2009