TRENDS IN MILK COMPOSITION AND ANALYSIS IN NEW YORK

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INTRODUCTION

The change to multiple component pricing in a wider geographic area of the federally regulated areas of the United States milk supply is part of the change that will occur with the reorganization of the USDA Federal Milk Marketing (FMM) orders that is planned to take place on October 1, 1999. In the past there have been different types of milk payment and pricing systems in different geographic regions of the United States even under the Federal Milk Marketing Orders. Even though more areas of the United States will be paying dairy farmers on the basis of milk components, the payment system will not be uniform across the country. In addition, in unregulated areas the payment system will still be based on an agreement between the milk buyer and the milk seller. However, in FMM regulated areas combinations of some or all of the following milk characteristics will be used in the pricing system: fat, true protein, solids-not-fat, other solids, and somatic cell count (SCC). Milk processors will still be free to pay quality bonuses based on absence of antibiotics, absence of added water, low bacteria counts, and SCC (in areas where somatic cell count is not included in the federally regulated price). The pricing system is still based on weight of components delivered to the processing plant. The new milk pricing system does not specifically place a higher value on milk with higher concentration of components.

Historically in the New York State (NYS), the regulated payment system has been for weight of fat and weight of milk delivered. Any payments for protein, solids-not-fat, other solids, or quality (e.g., low SCC or bacteria counts) have been incentive premium payments to the producer on top of federal minimum prices. However, there was one aspect of the NYS law that was unique in United States with respect to payment of dairy farmers. That was payment for protein in a voluntary system had to be on a true protein basis not a crude protein (i.e., total nitrogen basis). The change in the FMM program this year will convert the basis for protein payments to dairy farmers in all federally regulated areas to a true protein basis. Both Australia and France also pay their dairy farmers on a true protein basis. True protein plus nonprotein nitrogen (x 6.38) equal crude protein. The major component and the most variable component of the nonprotein nitrogen portion of milk is urea. The reason for the change to a true protein basis is two fold: 1) the nonprotein nitrogen component of milk does not have the same economic value as true protein and 2) the accuracy of electronic milk protein testing by infrared analysis is improved by using true protein as the basis for calibration instead of crude protein. Using true protein as the basis for calibration produces more accurate infrared milk analysis data when calibration is done properly and will provide better data for use in feeding management for dairy cows and genetic selection, if this basis for protein analysis is utilized for DHIA record keeping in addition to milk payment testing.

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OFFICIAL REFERENCE METHODS FOR MILK TESTING

What are the methods used for official reference testing in the USDA FMM system? All methods are official methods of the Association of Official Analytical Chemists International (AOACI) that have been validated by collaborative studies (Table 1). Fat and true protein are measured directly, while other solids is calculated from the results of three official methods.

Table 1. Official milk component testing reference methods identification numbers from the 16th edition of Official Methods of Analysis of the Association of Official Analytical Chemists International (1995).

Milk component	Method name	Method Number
fat	Modified Mojonnier	989.05
true protein	Protein Nitrogen	991.22
solids-not-fat	Solids-not-fat	990.21
total solids	Total Solids	990.20
other solids	(By difference)	(990.20 - (989.05 + 991.22)

The results of these methods on milk samples are used as the basis of calibration of infrared milk analyzers. Technically, these methods could be used directly for payment testing but they are too slow and expensive. However, periodically they may be used as a reference to verify testing results obtained in an industry testing lab. In most FMM Orders it is required that milk from all producers that do not belong to a cooperative be tested for payment by the FMM Laboratory or a laboratory that is under contract to that FMM Order. If a milk producer is a member of a cooperative, then the milk may be tested by the laboratory of that cooperative with periodic verification of testing accuracy by the staff of the FMM laboratory or their designee. Historically, in NYS the designee for the FMM Administrator has been the Division of Milk Control of NYS Agriculture and Markets

ROUTINE MILK ANALYSIS

Most routine milk analysis is done by mid-infrared transmission spectrophotometry. These instruments when coupled with an electronic milk somatic cell counter can test a large number of samples at a reasonable cost. The reference methods listed in Table 1 are the basis for calibration of infrared milk analyzers. It must be recognized that infrared milk analysis is a secondary method that is designed to predict the test value that the reference test would have provided on any particular sample. In making these predictions there are many assumptions and not every infrared milk analyzer test will agree exactly with the reference method. The goal is to achieve a mean test of a large group of milk samples that agrees very well with the mean test by the reference method with the variation in residual differences between the reference method small and normally distributed around a mean difference of zero.

The basic technology for mid-infrared milk analysis has been a discrete filter based approach where sample wavelength and reference wavelength filters were rotated into the beam of infrared light that was passed through the milk sample. These filters selected bands of wavelengths of light that can be used to measure the fat, protein, and lactose content of milk samples. This relatively simple approach has served the industry very well for over 20 years. However, there are some limitations to this approach, particularly when specific feeding practices change the concentrations of minor compounds in milk that may absorb light at the wavelengths used to measure the major components. Recently, advances in electronic technology and the relatively inexpensive computing power of microprocessor chips has made it possible to use full infrared spectra data. This power full new tool for milk testing offers the potential to improve the accuracy of payment testing by reducing the residual differences between reference chemistry and instrument predictions Possibly even more important from an animal science and management point of view is the potential for simultaneously measuring variation in minor components in milk that are related to the nutrition or health status of the dairy cow. In my opinion, it will take many years to discover and develop the full potential of what is called Fourier Transform Infrared (FTIR) milk analysis The first example of the measurement and use of data on a minor component in milk is the measurement of urea by infrared milk analysis. The first version of this technique was available on a filter based instrument using a partial least squares calibration, but in the future the routine measurement of urea is more likely to be done by FTIR analysis.

MILK COMPOSITION IN NEW YORK STATE

The most complete historical data on component milk composition in NYS are from the study by Herrington et al. (1) and Barbano (2). Herrington et al found a mean fat content of 3.53 and a mean total protein content of 3.13 in 860 milks over the period from 1959 to 1961. Summary data for NYS from the 1984 study by Barbano are shown in Table 2. Both crude protein and true protein are shown in Table 2. The data show the typical seasonal variation with concentrations of milk components being lower in the hot summer months. The seasonal variation in casein as a percentage of crude protein is larger than the seasonal variation in casein as a percentage of true protein. This is caused by the fact that the variation in casein as a percentage of crude protein is influence by variation in nonprotein nitrogen content of the milk, while casein as a percentage of true protein is not. Since the study by Barbano in 1984, there has been no comprehensive record keeping and publication on any milk component except fat. Milk fat data has been published (3) annually by the NYS Department of Agriculture and Markets (Table 3). The seasonal variation in fat concentration is similar to the data from the 1984 study (Table 2), but in general the average fat content of the milk was a little lower in the 1984 season compared to the 1988 to 1998 data in Table 3. The study by Barbano (2) was a national milk composition study that indicated that in general in the Northeast the protein content of the milk was lower than in some other regions of the country

From 1992 to 1998, the milk analysis laboratory at Cornell has monitored the composition of the milk protein fraction of the bulk milk supply received at three large cheese factories in NYS. The milks were collected from large milk silos daily and frozen in a low temperature culture freezer at the factory. One time each month the frozen samples were shipped to Cornell, thawed using a rapid microwave procedure, composited for the month, and analyzed immediately by the AOACI reference procedures for protein testing. Casein was determined using AOACI procedure number 998.07and nonprotein nitrogen was determined using procedure 991.21 The data for the composition analysis of the milk protein fraction are shown in Tables 4 through 9. In looking at these data one thing that can be noticed is the general stability of the average data from year to year. The patterns of seasonality are similar to previously reported data, with lowest concentrations in the summer months. However, in general the total concentration of both crude (Table 4) and true protein (Table 5) are lower

Table 2 New York State milk composition from 1984 study by Barbano (ref. 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Fat	3.73	3.61	3.60	3.55	3.53	3.44	3.37	3 40	3.57	3 69	3.70	3.68	3.57
Protein													
Crude	3 28	3.20	3.22	3.22	3 18	3.18	3.10	3.14	3.22	3 31	3.30	3.29	3 22
TRUE	3.13	3.06	3.08	3.07	3 01	3.00	2.94	2.97	3.05	3.15	3.15	3.13	3.06
Casein	2.57	2.52	2.51	2.52	2.47	2.45	2.41	2.42	2.49	2.58	2.59	2.58	2.51
C%TP	82.11	82.35	81.49	82.08	82 06	81.67	81.97	81.48	81 64	81.90	82.22	82.43	81.95
C%CP	78.49	78.20	78.14	78.20	77.76	77 21	77.70	77 03	77.51	77.80	78.55	78.56	77.93

C%TP = casein as a percentage of true protein; C% CP = casein as a percentage of crude protein

Table 3. Average milk fat test (%) of milk received from NYS dairy farmers by month (NYS Ag & Markets, ref. 3)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1988	3.73	3.71	3.72	3 69	3.65	3.55	3.54	3.52	3.67	3.77	3.81	3.79	3.68
1989	3.77	3 76	3.78	3.74	3.71	3.62	3.55	3.56	3.66	3 76	3.78	3.82	3.71
1990	3.73	3.70	3.70	3 68	3.63	3.55	3.53	3.54	3.61	3 71	3.75	3.73	3.66
1991	3.72	3.70	3.70	3.68	3.62	3.52	3.52	3.54	3.60	3.75	3.79	3.76	3.66
1992	3.75	3 76	3 77	3.75	3.70	3.61	3.61	3.63	3 65	3.77	3.82	3.77	3.72
1993	3.72	3.74	3.75	3.69	3.62	3.54	3.48	3.52	3.59	3.74	3.73	3.76	3 66
1994	3.77	3.74	3 72	3.69	3 66	3.53	3.50	3.52	3.62	3.70	3.72	3.73	3.66
1995	3 69	3.71	3.69	3.68	3.62	3.52	3.48	3.47	3.61	3.71	3.80	3.80	3.65
1996	3 78	3.75	3.76	3.73	3 69	3 58	3.58	3.58	3.62	3 75	3.79	3.76	3.70
1997	3.74	3.72	3 72	3.70	3 67	3 56	3 52	3.55	3 63	3.73	3 80	3.78	3.68
1998	3.73	3 73	3 74	3.69	3 62	3.57	3.52	3.53	3 59	3.71	3.80	3.75	3 67
Average	3 74	3.73	3 73	3.70	3 65	3 56	3 53	3.54	3 62	3 74	3 78	3.77	3.67

Table 4. Average milk crude protein test (%) of milk received at three large cheese factories in NYS.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	3.15	3.13	3.13	3.10	3.12	3.09	3.04	3.10	3.10	3.25	3.20	3.17	3.13
1993	3.15	3.18	3.18	3.09	3.11	3.08	2.99	3.04	3.13	3.22	3.25	3.22	3.14
1994	3.21	3.18	3.15	3.11	3.13	3.07	3.02	3.08	3.17	3.23	3.23	3.20	3.15
1995	3.18	3.20	3.19	3.14	3.09	3.05	2.99	3.03	3.15	3.26	3.18	3.20	3.14
1996	3.17	3.20	3.15	3.11	3.10	3.05	3.03	3.04	3.11	3.18	3.21	3.16	3.13
1997	3.19	3.16	3.13	3.13	3.10	3.08	3.04	3.07	3.14	3.18	3.18	3.19	3.13
1998	3.14	3.15	3.13	3.08	3.09	3.04	3.01	3.02	3.12	3.19	3.26	3.20	3.12
Average	3.17	3.17	3.15	3.11	3.10	3.07	3.02	3.06	3.13	3.22	3.22	3.19	3.13

Table 5. Average true protein test (%) of milk received at three large cheese factories in NYS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	2.97	2.94	2.95	2.92	2.93	2.89	2.84	2.90	2.90	3.06	3.02	2.98	2.94
1993	2.97	2.98	3.00	2.89	2.92	2.89	2.80	2.85	2.99	3.06	3.07	3.03	2.95
1994	3.02	3.00	2.97	2.91	2.92	2.87	2.82	2.89	2.96	3.04	3.04	3.01	2.95
1995	2.99	2.99	2.97	2.95	2.89	2.86	2.79	2.84	2.96	3.04	3.01	3.00	2.94
1996	2.98	3.00	2.96	2.93	2.90	2.85	2.84	2.84	2.92	2.99	3.02	2.98	2.93
1997	3.00	2.96	2.94	2.92	2.90	2.88	2.85	2.90	2.95	2.99	3.00	3.00	2.94
1998	2.95	2.96	2.94	2.89	2.89	2.85	2.83	2.83	2.92	3.01	3.04	3.02	2.93
Average	2.98	2.98	2.96	2.92	2.91	2.87	2.82	2.86	2.94	3.03	3.03	3.00	2.94

than the values for the 1984 study. The magnitude of this difference is very important with respect to its impact on cheese yield The nonprotein nitrogen (x 6.38) data are shown in Table 6 These values are higher than those observed by calculating the difference between the crude and true protein values in Table 2. This is partly due to a difference in analytical method. In the 1984 study, the methodology for measurement of nonportein nitrogen content was not standardized and the method used in 1984 would be expected to provide values that are 0.02% lower than the method used to produce the 1992 to 1998 data. However, even when this is taken into account, it appears that milk nonprotein nitrogen may be somewhat higher now that it was in 1984 The casein percentage in milk (Table 7) for the period 1992 to 1998 is lower than the casein percentage reported in the 1984 study and this is consistent with the lower true protein content of the milk during this same period. Casein as a percentage of true protein (Table 8) and casein as percentage of crude protein (Table 9) are generally comparable to the values found in the 1984 study It is best to compare casein as a percentage of true protein (since its value is not influenced by variation in nonprotein nitrogen). When this comparison is made, the values are remarkably close and would indicate that while the concentration of components has changed the relative rate of synthesis of caseins and milk serum proteins within the milk protein fraction has remained unchanged. The slight increase in casein as a percentage of true protein may reflect a reduction in milk somatic cell count over this period.

The differences in the data for concentration of milk components in the milk supply in NYS seems to be consistent with the milk pricing message that has been sent to producers over the past 20 years. The regulated payment system in NYS has provided the signal to producers to deliver fat and volume. The concentration of fat in milk seems to be slightly higher, data from NYS Agriculture and Markets and USDA would indicate the milk volume per cow has increased over this period (data not shown), and the concentration of protein in milk is lower. The lower concentration of milk protein would be consistent with the higher milk volume per cow and the fact that protein has not been a part of the regulated payment system in NYS.

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Table 6 Average nonprotein nitrogen test (%N x 6.38) of milk received at three large cheese factories in NYS.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	0.180	0.185	0.182	0.180	0.186	0.200	0.198	0.201	0.198	0.189	0.183	0.185	0.189
1993	0.185	0.194	0.180	0.198	0.191	0.194	0.190	0.194	0.140	0.155	0.187	0.189	0.183
1994	0.195	0.180	0.188	0.196	0.202	0.198	0.196	0.194	0.212	0.187	0.195	0.192	0.195
1995	0.187	0.205	0.216	0.195	0.197	0.197	0.199	0.196	0.195	0.218	0.178	0.202	0.199
1996	0.187	0.202	0.191	0.183	0.195	0.197	0.198	0.201	0.194	0.190	0.192	0.183	0.193
1997	0.187	0.191	0.196	0.208	0.206	0.199	0.188	0.171	0.191	0.191	0.188	0.191	0.192
1998	0.186	0.184	0.192	0.186	0.197	0.186	0.184	0.184	0.195	0.185	0.222	0.188	0.191
Average	0.187	0.192	0.192	0.192	0.196	0.196	0.193	0.191	0.189	0.188	0.192	0.190	0.192

Table 7. Average casein test (%) of milk received at three large cheese factories in NYS.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	2.43	2.42	2.43	2.41	2.40	2.38	2.33	2.38	2.38	2.53	2.48	2.44	2.42
1993	2.45	2.47	2.47	2.39	2.40	2.37	2.30	2.34	2.42	2.49	2.53	2.50	2.43
1994	2.49	2.47	2.46	2.41	2.42	2.37	2.32	2.37	2.44	2.50	2.50	2.47	2.43
1995	2.47	2.45	2.45	2.42	2.39	2.36	2.29	2.32	2.43	2.50	2.46	2.46	2.41
1996	2.45	2.46	2.42	2.40	2.39	2.35	2.33	2.34	2.39	2.45	2.48	2.45	2.41
1997	2.47	2.44	2.42	2.40	2.39	2.38	2.35	2.38	2.42	2.45	2.46	2.47	2.42
1998	2.43	2.43	2.42	2.38	2.37	2.35	2.32	2.33	2.40	2.46	2.51	2.48	2.41
Average	2.46	2.45	2.44	2.40	2.40	2.36	2.32	2.35	2.41	2.48	2.49	2.47	2.42

Table 8. Average casein as a percentage of true protein at three large cheese factories in NYS.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	81.85	82.12	82.34	82.39	82.03	82.28	82.14	82.15	82.28	82.41	82.14	81.91	82.17
1993	82.49	82.95	82.30	82.73	82.22	82.02	82.22	82.19	80.83	81.15	82.45	82.51	82.17
1994	82.56	82.43	82.80	82.68	82.73	82.43	82.18	82.12	82.46	82.21	82.41	82.00	82.42
1995	82.49	81.92	82.27	82.12	82.48	82.56	82.02	81.80	82.25	82.20	81.71	81.98	82.15
1996	82.10	82.09	81.76	82.09	82.50	82.41	82.17	82.21	81.81	82.17	82.11	82.08	82.12
1997	82.32	82.39	82.36	82.31	82.53	82.59	82.40	82.16	81.99	82.11	82.24	82.30	82.31
1998	82.23	81.89	82.26	82.21	82.09	82.33	82.03	82.28	82.27	81.71	82.82	82.15	82.19
Average	82.29	82.26	82.30	82.36	82.37	82.38	82.16	82.13	81.98	81.99	82.27	82.13	82.22

Table 9 Average casein as a percentage of crude protein at three large cheese factories in NYS

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1992	77.17	77.26	77.56	77.61	77.14	76.94	76.80	76.82	77.01	77.63	77.44	77.12	77.21
1993	77.66	77.88	77.64	77.42	77.18	76.85	76.99	76.95	77.21	77.25	77.72	77.66	77.37
1994	77.55	77.77	77.86	77.46	77.39	77.13	76.84	76.96	76.93	77.44	77.44	77.07	77.32
1995	77.63	76.66	76.69	77.02	77.22	77.23	76.55	76.52	77.15	76.71	77.13	76.80	76.94
1996	77.24	76.90	76.81	77.26	77.31	77.10	76.79	76.79	76.71	77.26	77.20	77.33	77.06
1997	77.50	77.40	77.20	76.83	77.05	77.25	77.30	77.58	77.01	77.19	77.38	77.39	77.26
1998	77.37	77.10	77.22	77.24	76.86	77.29	77.01	77.26	77.11	76.98	77.18	77.34	77.16
Average	77.45	77.28	77.28	77.26	77.16	77.11	76.90	76.98	77.02	77.21	77.36	77.24	77.19