Economic Returns to Holstein and Jersey Herds Under Multiple Component Pricing

K. W. Bailey,¹ C. M. Jones,² and A. J. Heinrichs²

¹Department of Agricultural Economics and Rural Sociology, and

²Department of Dairy and Animal Science, The Pennsylvania State University, University Park, 16802

ABSTRACT

This study analyzed component data from herds participating in the Mideast Federal Milk Marketing Order from 2000 through 2002, and its implications for herd profitability. A monthly simulation model was developed to evaluate the economic returns for a representative Holstein and Jersey herd in Pennsylvania under multiple component pricing. Component levels were highly seasonal and variable from farm to farm. A third of the herds during the course of a year realized a 1- to 3-mo temporary reduction in milk fat or protein greater than one standard deviation. Consistently producing milk fat and protein one standard deviation below the mean reduced the Class III value by \$0.82/cwt (100 pounds), or 7.09%. The simulation model indicated that a herd of 100 Holstein cows generated \$31,221 more income over feed costs (IOFC) a year than a herd of 100 Jersey cows. Although Jersey milk had greater gross value than Holstein milk due to higher component levels, total volume of milk and components produced by Holsteins offset this difference. Simulation results confirm that increasing milk fat and protein percentages by one standard deviation increased IOFC 7.7% for Holsteins and 9.2% for Jerseys relative to the baseline IOFC, with similar losses for component reductions. Increasing milk yield by one standard deviation increased IOFC by 19.6% for Holsteins and 23.9% for Jerseys relative to the baseline IOFC, again with similar losses for reductions in milk production. In all of the scenarios analyzed, the most important factor affecting IOFC was total amount of milk fat and protein produced, not the component percentage levels.

(**Key words:** milk composition, multiple component pricing)

Abbreviation key: cwt = 100 pounds, DRMS = Dairy Records Management System, GR = gross revenue,

IOFC = income over feed costs, PPD = producer price differential.

INTRODUCTION

Dairy producers shipping milk into United States federal milk marketing orders faced a new milk pricing system effective January 1, 2000, as a result of federal order reforms implemented by the USDA and initiated by the US Congress (Bailey and Tozer, 2001). Seven of the 11 federal milk marketing orders that were created use a multiple component pricing system that pays dairy producers on the basis of milk fat, true protein, and other dairy solids. The new pricing system derives component values from surveyed prices for manufactured dairy products (cheese, butter, nonfat dry milk, and dry whey), which rise and fall with changing market conditions. Thus, producers in federal orders now receive pricing signals from the wholesale and retail markets.

Under the previous regulations, producers were paid based on one price adjusted by milk fat content above or below 3.5%. Today they are paid a separate price for milk fat, true protein, and other dairy solids. These prices reflect the value of milk components in manufactured dairy products. In addition to this value, producers in federal orders also receive a producer price differential (PPD) each month. The PPD reflects the value of the federal order pool in a particular month above the manufacturing value (the statistical uniform price less the Class III price). The PPD is usually positive each month because Class I and II prices in federal orders are usually higher than Class III and IV prices due to mandated formulas that use differentials. Finally, some of the federal orders now pay producers a premium or discount each month according to their SCC level.

The implications of this new pricing system on farm profitability are not clearly understood. For example, is it more profitable to expand overall production by increasing productivity per cow? Or is it more profitable to maintain milk production per cow, but improve component levels for milk fat and protein by changing the

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Corresponding author: Kenneth W. Bailey; e-mail: baileyk@psu.edu.

feeding system or altering the genetic base of the herd? These are important factors to consider because 1) producers in federal milk marketing orders that use a multiple component pricing plan receive a substantial portion of their gross income from milk components, 2) producers have the ability to alter milk component levels to some degree, and 3) the relative price for milk fat and protein changes frequently with alternative market conditions creating income risk for producers.

A number of studies have analyzed the implications of alternative multiple component pricing schemes on farm income (Gruebele, 1982; Cragle et al., 1986; Kirkland and Mittelhammer, 1986). Other studies have focused more specifically on the economic returns by breed under multiple component pricing plans (Schmidt and Pritchard, 1988; Elbehri et al., 1994). Other studies have taken a broader look at the social welfare implications of switching to a multiple component pricing system (Perrin, 1980; Lenz et al., 1991; Gillmeister et al., 1996). Despite this large body of literature, no studies have been completed that evaluate the economic returns for actual herds from component performance since the most recent federal order reform.

The first objective of this study was to analyze the statistical properties of actual component data from herds participating in a federal milk marketing order in the Mideast and Northeast United States. In particular, we were concerned with the degree of dispersion of component data around the mean and its implications for profitability. The second objective was to develop a monthly simulation to evaluate the economic returns for Holstein and Jersey herds under the current multiple component pricing system.

MATERIALS AND METHODS

Data Acquisition and Processing

This study began with an analysis of milk component levels and SCC levels for producers participating in federal milk marketing orders. Of interest were the seasonality of component production and the monthly mean and standard deviations for protein, milk fat, other solids, and SCC. The strength of these data is that they contain observations for every participant in the federal order by month. The weakness of the data set, however, is that it is not differentiated by breed or by milk productivity per cow.

Our initial criteria for data collection was to identify a federal order that 1) contained a significant volume of milk each month from Pennsylvania producers, 2) used component pricing, and 3) was willing to provide at least 3 yr of data. Using these criteria, milk production, component levels, and price data were obtained from the USDA's Agricultural Marketing Service for Mideast

Federal Order 33. The data supplied by USDA provided a monthly summary of every producer who shipped milk into the Mideast federal order for the period January 2000 through December 2002. This order includes producers located mainly in Ohio, Michigan, Illinois, Indiana, and Western Pennsylvania. More specifically, the USDA data set included monthly records for farm identification code, total pounds of milk shipped, percentage fat, percentage protein, percentage other dairy solids, and SCC. The farm identification code was used to protect the identity of individual herds. During the period of study, producers in the Mideast federal order did not have every load of milk sampled and tested for milk components and SCC. Rather, they had their milk tested an average of 4 to 5 times per month.

The original data set contained 356,339 observations. After analysis of extreme observations using the UNIVARIATE procedure of SAS (SAS Institute, 1999), data were edited to exclude records as follows: milk fat or protein percentage >6%; other dairy solids percentage >6.5%; and SCC >3,000,000 cells. After edits, the total number of observations was 356,322. Production and component data for the Mideast order were then summarized by month and year using the MEANS procedure of SAS (SAS Institute, 1999).

To provide information related to breed and production per cow, data were obtained from Dairy Records Management Systems (DRMS), Raleigh, NC. Data were extracted from herd summary reports for Holsteins and Jerseys in PA, OH, IN, MI, WV, and WI. For each herd a single test date for each month of 2000, 2001, and 2002, was used. Data included breed, herd-level averages for milk (milking cows only), milk fat, protein, SCC, and linear SCS. The original data set contained 170,352 observations. Records missing year or month information were dropped from the data set. After analysis of extreme observations using the UNIVARIATE procedure (SAS Institute, 1999), data were edited to exclude records as follows: daily milk per cow <10 lb or >200 lb; milk fat percentage >9%; milk protein percentage >6%; somatic cell score >10; and SCC >3,000,000 cells or <10,000 cells. The total number of observations after edits was 166,025. Production and components from DRMS data were summarized by breed, month, and year using the MEANS procedure (SAS Institute, 1999).

A final source of data used in this study was feed prices from the Penn State Team Dairy Web site (Ishler, 2001–2002). These data are collected monthly from several sources including the Pennsylvania Agricultural Statistics Service market summaries for hay and grain, Feedstuffs magazine market reports, and local agribusinesses. Prices are calculated and reported monthly via the Internet. This report was accessed each month

during 2001 and 2002 to develop a regional price database. All feed costs were provided in dollars per 100 pounds (**cwt**) of DM, which was converted to dollars per pound of DM for use in this study. Silage values in this report are calculated from values for dry hay expressed on a DM basis. Legume silage values are based on market prices for alfalfa hay, and corn silage values are based on market prices for grass hay. The corresponding value of silage DM is then used to calculate silage values at an average silage DM of 45% for legume silage and 33% for corn silage. For each ration ingredient, the feed cost used for simulation was a 2-yr average price that reflected regional feed costs for Pennsylvania dairy operations.

Simulation Model

An economic simulation model was developed to analyze the economic returns to milk production under alternative component levels for representative herds of Holstein and Jersey cows. The simulation model computed gross revenue (**GR**) by production and component level, feed costs, and income over feed costs (**IOFC**) by breed. The model also simulated the impact of producing above and below average component levels by breed.

Averages obtained from the federal order and DRMS datasets were used to develop simulated monthly revenues for milk deliveries for each breed; herd size of 100 cows was assumed. Gross revenues were calculated via the multiple component pricing formulas used in Federal Order 33 as follows:

$$GR^i = (\beta_{mf}^i * P_{mf}^i + \beta_{pr}^i * P_{pr}^i + \beta_{os}^i * P_{os}^i + P_{scc}^i/100 + PPD^i/100) * PRD^i \quad [1]$$

where GR^i = monthly gross revenue, i = month, β_k = percentage of component k for delivered milk (mf = milk fat, pr = protein, and os = other solids), P_k = price of component k per pound, P_{scc} = SCC adjustment in \$/cwt, PPD = producer price differential in \$/cwt, and PRD = pounds of delivered milk.

Pounds of milk delivered were assumed to equal pounds of monthly milk production identified as follows:

$$PRD^i = D^i * DAP^i * COWS^i \quad [2]$$

where D^i are the number of days in the month, DAP^i is daily average milk production, and $COWS^i$ are the number of cows milked each month.

The SCC adjustment is specified by the Mideast federal order as follows:

$$P_{scc}^i = (350 - SCC) * SCCR \quad [3]$$

where SCC = somatic cell count in thousands, and $SCCR$ is the somatic cell count rate in \$/cwt.

Finally, IOFC is specified as follows:

$$IOFC^i = GR^i - FC^i * D^i * COWS^i \quad [4]$$

where FC is feed costs per cow per day for month i . FC is specified as follows,

$$FC^i = \sum_k DM_k^i * PDM_k^i \quad [5]$$

where DM is pounds of DM per cow per day for feed component k in month i , and PDM is the price of DM k in month i in dollars per pound.

The data used to simulate monthly representative Holstein and Jersey herds in Pennsylvania were from the USDA federal order and DRMS datasets. The monthly baselines for daily average production, milk fat, protein, and SCC by breed were derived from the DRMS data set using a 3-yr average (2000 to 2002). The DRMS data set did not provide the percentage of other solids by breed. The yield of other solids does not vary as much as other components (Sharma et al., 1983; Rodriguez et al., 1997) and is not as valuable (USDA, 2000–2002). Therefore, for each month, a 3-yr average other solids value from the Mideast federal order data set was used for both Holsteins and Jerseys. Three-year average prices for each component, somatic cell count rate, and PPD were computed based on data obtained from the federal order market administrator's Web site (USDA, 2000–2002).

Gross revenue by itself does not adequately represent economic returns to each breed for a typical Pennsylvania dairy farm under a multiple component pricing system. For example, milk production and component levels respond in part to the nutrient intake of the cow. Feed costs are usually the largest variable expense incurred by dairy farms and should be considered in any measure of economic returns. There are other variable and fixed costs associated with milk production that also would be prevalent on a commercial Pennsylvania dairy farm. Some of these data are published each year by the Pennsylvania Farm Bureau Member's Service Corporation (MSC) Business Services (2002) and represent Pennsylvania and Northeast production costs for labor, feed, interest, rent, milk marketing, depreciation, and other costs. However, none of these data can be sorted by breed. In addition, these nonfeed expenses vary considerably from farm to farm. On the other hand, the relationships between milk yield and composition and feed requirements are well established and can be determined for different breeds (NRC, 2001). Therefore,

Table 1. Three-year average amount shipped and milk composition for dairy producers in Mideast Federal Order 33 from January 2000 through December 2002.

	n	Milk shipped, lb/farm		Fat, %		True protein, %		Other solids, %		SCC, 1000 cells/mL	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
January	29,693	130,315	260,785	3.90	0.32	3.11	0.19	5.64	0.12	326	181
February	29,693	125,733	283,722	3.87	0.31	3.09	0.18	5.65	0.12	334	185
March	29,694	138,613	310,451	3.85	0.30	3.07	0.18	5.66	0.11	331	178
April	29,692	138,730	310,952	3.79	0.29	3.03	0.17	5.68	0.12	334	178
May	29,694	142,134	311,288	3.68	0.30	3.02	0.17	5.70	0.11	334	173
June	29,695	135,313	296,254	3.62	0.28	2.97	0.16	5.68	0.11	353	177
July	29,695	136,203	300,563	3.56	0.26	2.92	0.16	5.66	0.12	393	191
August	29,694	131,579	291,000	3.57	0.27	2.94	0.16	5.64	0.12	415	201
September	29,693	129,847	288,725	3.66	0.28	3.04	0.16	5.63	0.13	382	183
October	29,694	132,843	306,969	3.81	0.31	3.13	0.18	5.63	0.13	342	169
November	29,694	128,752	302,244	3.89	0.32	3.16	0.19	5.63	0.13	318	163
December	29,691	132,808	321,339	3.93	0.33	3.14	0.19	5.64	0.13	334	177
All months	356,322	133,573	299,121	3.76	0.32	3.05	0.19	5.65	0.12	350	182

for the purposes of this study, only feed costs were used to compare production expenses by breed.

Income over feed cost was calculated monthly for representative Holstein and Jersey herds. Feed costs were determined by estimated feed requirements and 2-yr regional average prices for ration ingredients (Ishler, 2001–2002). For each month, DMI was estimated for each breed based on the 3-yr average milk yield and composition derived from the DRMS data set. Intake requirements were estimated for a ration containing corn silage at 35% DM (Int. Feed No. 3-28-248), legume silage at 43% DM (Int. Feed No. 3-07-797), dry ground corn (Int. Feed No. 4-02-854), soybean meal (Int. Feed No. 5-20-638), and a mineral-vitamin mix (NRC, 2001). Silage was constrained to 60% of ration DM (30% from each source) and the mineral-vitamin mix was limited to 2% of DM. The amount of corn and soybean meal required was determined using NRC (2001) ration evaluation software. Protein was the first-limiting nutrient in this diet, so corn and soybean meal amounts were adjusted until the entered milk production was within 1 lb of the yield allowed by metabolizable protein (as predicted by the NRC model). Feed requirements were estimated individually for each month and breed.

RESULTS AND DISCUSSION

Analysis of the Data

Preliminary analysis of the USDA data from Federal Order 33 for the period January 2000 through December 2002 is presented in Table 1. The results indicate that milk fat and protein component levels vary seasonally, as expected. In addition, the standard deviation for milk fat (0.32%) is roughly twice that of either protein (0.19%) or other dairy solids (0.12%). The standard deviation for SCC is 55.5% of the mean, indicating a large

dispersion around the mean. These initial results imply that there are large differences in the farm value of milk components among producers in the Mideast federal order in any given month and that there is a strong seasonal pattern for component production.

The seasonal variation in milk composition derived from the data provides important input for analysis of economic returns to milk production (Allore et al., 1997). The data in Table 1 indicate that milk fat and protein percentages were highest in the fall, winter, and spring months and lowest in the summer months. These seasonal changes in milk composition are consistent with previous reports of milk component variation in the Northeast (Allore et al., 1997). In addition, variation in milk composition between herds in any given month was large, indicating that many herds have an opportunity for improving component production.

An initial statistical analysis of the data produced 12 separate means over 3 yr for each component (milk fat, protein, and other dairy solids). This method of analysis could obscure a simple observation of dispersion around the mean. Thus, the monthly data in Table 1 were adjusted to remove seasonal effects, which allowed the monthly data to be combined to isolate the deviation of individual observations around the mean. The seasonal adjustment was calculated by dividing the 3-yr average for each month by the overall average. This adjustment value was then applied to each observation to produce a new data set.

Variation in this new data set was not decreased by the adjustment for seasonal effects (Table 2). In the original data set, milk fat percentage was $3.76 \pm 0.32\%$ and protein was $3.05 \pm 0.19\%$. After seasonal adjustment, milk fat percentage was $3.76 \pm 0.30\%$ and protein was $3.05 \pm 0.17\%$. This minimal change indicates that many factors other than season contribute to the wide

Table 2. Three-year average amount shipped and milk composition for dairy producers in Mideast Federal Order 33 from January 2000 through December 2002 after adjustment for seasonal differences.¹

	n	Milk shipped, lb/farm		Fat, %		True protein, %		Other solids, %		SCC, 1000 cells/mL	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
January	29,693	133,574	267,308	3.76	0.31	3.05	0.19	5.65	0.12	350	194
February	29,693	133,573	301,415	3.76	0.30	3.05	0.18	5.65	0.12	350	194
March	29,694	133,577	299,172	3.76	0.29	3.05	0.18	5.65	0.11	350	188
April	29,692	133,574	299,395	3.76	0.29	3.05	0.17	5.65	0.12	350	186
May	29,694	133,572	292,536	3.76	0.30	3.05	0.17	5.65	0.11	350	181
June	29,695	133,577	292,453	3.76	0.29	3.05	0.16	5.65	0.11	350	176
July	29,695	133,572	294,756	3.76	0.28	3.05	0.16	5.65	0.12	350	170
August	29,694	133,569	295,401	3.76	0.28	3.05	0.16	5.65	0.12	350	170
September	29,693	133,574	297,011	3.76	0.29	3.05	0.17	5.65	0.13	350	168
October	29,694	133,578	308,667	3.76	0.30	3.05	0.17	5.65	0.13	350	173
November	29,694	133,574	313,564	3.76	0.31	3.05	0.18	5.65	0.13	350	179
December	29,691	133,570	323,181	3.76	0.32	3.05	0.19	5.65	0.13	350	185
All months	356,322	133,574	299,015	3.76	0.30	3.05	0.17	5.65	0.12	350	181

¹Seasonal adjustment was calculated by dividing the 3-yr average for each month by the overall average. This adjustment value was then applied to each observation to produce a new data set.

variation in milk component production. The distributions of milk fat and protein percentage after adjusting for the effects of season are shown in Figures 1 and 2, respectively. The distribution of SCC after adjustment for season is shown in Figure 3. Before adjustment, SCC averaged $350,000 \pm 182,000$ cells/mL; after seasonal adjustment, SCC averaged $350,000 \pm 181,000$ cells/mL.

Although SCC is not normally distributed (evidenced by skewness of 1.22 and kurtosis of 2.89), these results suggest that many factors other than season contribute to the wide variation in SCC.

For each observation in the original data set, the Class III value of milk shipped was computed according to the formula used in Federal Order 33. The Class III

Figure 1. Distribution of fat percentage in milk marketed in Mideast Federal Order 33 from 2000 to 2002 after adjustment for effect of season. Solid line indicates the mean (3.76%), and dashed line indicates standard deviation ($\pm 0.30\%$) over the 3-yr period.

Figure 2. Distribution of true protein percentage in milk marketed in Mideast Federal Order 33 from 2000 to 2002 after adjustment for effect of season. Solid line indicates the mean (3.05%), and dashed line indicates standard deviation ($\pm 0.17\%$) over the 3-yr period.

Figure 3. Distribution of SCC in milk marketed in Mideast Federal Order 33 from 2000 to 2002 after adjustment for effect of season. Solid line indicates the mean (350,000 cells/mL), and dashed line indicates standard deviation ($\pm 181,000$ cells/mL) over the 3-yr period.

Table 3. Three-year average monthly amount shipped, milk composition, and Class III values for producers in Mideast Federal Order 33 from January 2000 through December 2002.

Category ¹	n	Milk shipped, lb/mo		Fat, %		True protein, %		SCC, 1000 cells/mL		Class III value, \$/cwt	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<50,000	112,534	31,172	11,609	3.83	0.38	3.08	0.23	389	215	\$11.70	\$2.16
50,001 to 100,000	110,766	72,006	14,115	3.75	0.31	3.04	0.18	359	179	\$11.61	\$2.09
100,001 to 500,000	121,001	190,090	87,858	3.72	0.27	3.03	0.15	313	145	\$11.53	\$2.03
>500,000	12,021	1,090,598	1,220,788	3.61	0.23	3.00	0.12	268	108	\$11.40	\$1.98

¹Categorized by pounds of milk shipped per month.

value aggregates the federal order values of each milk component in 1 cwt of milk. Class III value was computed as follows:

$$\text{ClassIIIvalue}^i = (\beta_{mf}^i * P_{mf}^i + \beta_{pr}^i + P_{pr}^i + \beta_{os}^i * P_{os}^i) * 100 \quad [6]$$

The USDA data set for Federal Order 33 provided data for the entire population of producers who sold milk into the Mideast order over a 3-yr period. To evaluate the effects of herd size on milk components and SCC, each observation was assigned to one of the following categories, based on amount of milk shipped per month: <50,000 pounds, 50,001 to 100,000 pounds, 100,001 to 500,000 pounds, or >500,000 pounds. The data were then summarized by these categories of milk shipped (Table 3). The results indicate that smaller producers had higher levels of milk fat and protein, and thus a higher Class III value (\$/cwt), than larger producers. On the other hand, SCC levels were much higher for smaller producers than for larger producers. In addition, the standard deviation was greater for milk fat, protein, and Class III value for smaller producers than for larger producers.

Next, the USDA federal order data set was analyzed to determine the percentage of herds that were consistently low in terms of milk fat, protein, and SCC. These herds were arbitrarily divided into 2 classes: short-term herds that deviated by more than one standard deviation from the monthly mean for 1 to 3 mo of a year; and persistent herds that deviated by more than one standard deviation from the monthly mean for 9 or more months out of a year. In particular, we were interested in quantifying how many herds in the data set had low levels of milk fat, protein, and Class III value, and high SCC. Regardless of the cause, these conditions negatively influence farm revenues.

One weakness with this approach, however, is that the population includes both Holsteins and Jersey herds. Jersey herds would likely raise the population mean for components. Unfortunately, this data set can-

not be sorted by breed. Thus, any Jersey herds that realized a decrease of more than one standard deviation from the mean for the Jersey group would not be measured by this analysis because the mean and standard deviation was computed for the entire population.

The concept of a herd-year was used in this analysis. A herd-year was defined as one observation that consisted of a herd code, year, and 12 mo of milk component data. Each herd could have up to 3 yr represented in the data set. For each herd-year, monthly production of milk fat, protein, and SCC were compared with the 3-yr monthly average of milk fat, protein, and SCC, and a rate of attainment (number of months out of that year) was calculated for each of the following: low milk fat = milk fat percentage > one standard deviation below the mean; low protein = protein percentage > one standard deviation below the mean; low milk fat and protein = both milk fat and protein percentages > one standard deviation below their respective means; high SCC = SCC > one standard deviation above the mean. The frequency of these rates of attainment was then calculated using the FREQ procedure of SAS (SAS Institute, 1999). These frequencies did not provide the actual number of herds meeting the above criteria because each herd had a potential of 3 observations (1 per year). Therefore, frequency of each herd code was determined to provide the actual number of herds in each category.

The performance analysis identified 12,445 unique herds that participated in the Mideast federal order over a 3-yr period (Table 4). Over that time, 4.8 and 4.4% of the herds consistently had low milk fat or protein levels for 9 or more months of the year. Low component production for most of a year could result from herd genetics or management factors including nutrition or disease. In addition, 9.7% of all herds had a SCC > one standard deviation above the mean for 9 or more months of the year. Although the exact cause is not known, consistently high SCC most likely resulted from mastitis infection in the herd. Regardless of their origin, these consistent problems cost producers money and present an opportunity for improved profitability.

Table 4. Consistency of herd performance for dairy producers in Mideast Federal Order 33 considering the number of years data were collected during the period January 2000 to December 2002.

	Years of data collected			Total
	1	2	3	
All herds				
No. of herds	2595	2450	7400	12,445
% total herds	20.9	19.7	59.5	100.0
Short-term low performance ¹				
Low milk fat				
No. of herds	568	829	3305	4702
% herds	21.9	33.8	44.7	37.8
Low protein				
No. of herds	667	727	3049	4443
% herds	25.7	29.7	41.2	35.7
Low milk fat and protein				
No. of herds	285	393	1506	2184
% herds	11.0	16.0	20.4	17.5
High SCC				
No. of herds	543	787	3198	4528
% herds	20.9	32.1	43.2	36.4
Persistent low performance ²				
Low milk fat				
No. of herds	57	64	473	594
% herds	2.2	2.6	6.4	4.8
Low protein				
No. of herds	76	108	359	543
% herds	2.9	4.4	4.9	4.4
Low milk fat and protein				
No. of herds	7	10	60	77
% herds	0.3	0.4	0.8	0.6
High SCC				
No. of herds	154	182	869	1205
% herds	5.9	7.4	11.7	9.7

¹Herds that deviated by more than one standard deviation from the monthly mean for 1 to 3 mo of a year.

²Herds that deviated by more than one standard deviation from the monthly mean for 9 or more months of a year.

We also determined the number of herds with short-term low performance; these herds had low milk fat and protein or high SCC, or both, for a 1- to 3-mo period in any year. The analysis suggests that 37.8 and 35.7% of all herds that shipped milk into the Mideast Federal Order fit this description for low levels of milk fat and protein, respectively. These herds were average or above average in milk component levels for a majority of the year, which indicated that herd genetics were not responsible for short-term below average performance. Instead, it is likely that management changes or oversights allowed performance to falter. These producers likely could benefit from monitoring systems and improved management practices that would identify and correct milk component and SCC problems earlier, thus providing an opportunity to enhance profitability.

A final question addressed using the USDA federal order data was quantification of the loss in Class III value for a typical producer with milk fat and protein levels one standard deviation below the mean. An average Class III value was produced using equation 6 and

average component levels and prices computed over the 3-yr period from the federal order data set (Table 1). This equation was recalculated after reducing milk fat and protein levels by one standard deviation. The results indicated that during this 3-yr period, producing milk with milk fat one standard deviation below average reduced the Class III value by \$0.46/cwt, or 4.02%. Milk with low protein was worth \$0.36/cwt or 3.07% less. Finally, milk with both milk fat and protein one standard deviation below the mean reduced the Class III value by \$0.82/cwt or 7.09%.

Simulated IOFC

The next step in this study was to complete the monthly simulation for representative 100-cow Holstein and Jersey herds utilizing relevant pricing information for milk components and feed ingredients to compute both GR and IOFC.

Breed is a known factor that affects milk component production (Sharma et al., 1983). To quantify these differences, we summarized test day milk production and composition data provided by DRMS by breed. Differences between Holsteins and Jerseys are clearly demonstrated in Tables 5 and 6. Holsteins produced about 20 lb/d more milk than Jerseys. In addition, test-day protein and milk fat were 0.5 and 1.0 percentage points greater for Jerseys than Holsteins. These disparities are in the same range as previous reports of breed differences (Sharma et al., 1983; Rodriguez et al., 1997).

Milk component values and ration ingredient costs used in calculating IOFC are presented in Table 7. The pricing information in Table 7 was combined with equations 1 through 5 and breed information in Tables 5 and 6 to produce the baseline results in Table 8.

For the baseline scenario, Holstein production for 100 cows was 66.0 lbs/d with 3.72% fat and 3.03% protein, resulting in annual production of 2.41 million lbs of milk, GR of \$315,853, total feed costs of \$107,514, and \$208,339 in annual IOFC. The baseline Jersey production for 100 cows was 46.2 lbs/d with 4.67% fat and 3.57% protein. This resulted in annual production of 1.69 million lbs of milk, \$261,323 in GR, \$84,205 in feed costs, and annual IOFC of \$177,118. The baseline results indicate that a herd of 100 Holstein cows generated \$31,221 more IOFC than a herd of 100 Jersey cows. Jersey milk had a higher gross value per hundred-weight than Holstein milk, \$15.49/cwt and \$13.12/cwt, respectively; however, the total volume of milk and components produced by Holsteins offset this price difference.

Alternative Scenarios

The results for IOFC described above are for a 100-cow Holstein or Jersey herd producing an average vol-

Table 5. Three-year average milk yield (milking cows only) and composition of Holsteins on DHIA test¹ from PA, OH, IN, WV, WI, and MI from January 2000 through December 2002.

	n	Test-day milk yield, lb/cow per d		SCC, 1000 cells/mL		n	Fat, %		True protein, %	
		Mean	SD	Mean	SD		Mean	SD	Mean	SD
January	13,198	66.7	11.4	307	179	13,025	3.8	0.4	3.1	0.2
February	12,786	67.6	11.4	310	181	12,603	3.8	0.4	3.1	0.2
March	13,486	68.0	11.2	312	184	13,294	3.8	0.4	3.1	0.1
April	12,938	68.3	11.1	309	177	12,782	3.8	0.4	3.0	0.1
May	13,311	68.6	10.8	302	168	13,188	3.7	0.4	3.0	0.1
June	12,930	66.8	10.5	314	169	12,815	3.6	0.3	2.9	0.1
July	13,144	65.2	10.7	344	182	13,034	3.6	0.3	2.9	0.1
August	13,039	63.7	10.5	370	194	12,933	3.6	0.3	2.9	0.1
September	12,699	63.6	10.8	357	190	12,596	3.7	0.3	3.0	0.1
October	13,116	63.6	10.9	320	174	13,013	3.8	0.3	3.1	0.1
November	13,265	64.1	11.0	310	171	13,175	3.8	0.3	3.1	0.1
December	14,413	65.4	11.4	314	176	14,348	3.8	0.3	3.1	0.1
All months	158,325	66.0	11.1	322	180	156,806	3.7	0.4	3.0	0.2

¹Data obtained from Dairy Records Management Systems, Raleigh, NC.

ume of milk with average component levels. Of particular interest is how IOFC would change under alternative scenarios. For example, how much would results change if the Holstein or Jersey herds were to improve milk production or component levels? This would require additional feed, but could improve IOFC. More importantly, what are the IOFC implications for producing components below the baseline averages?

A number of scenarios were developed for both the Holstein and Jersey herds to simulate these alternative impacts on IOFC. These scenarios are described as follows:

1. Increase components – Production of milk fat and protein were increased from the baseline by one standard deviation. For Holsteins, component levels were elevated to 4.09% milk fat and 3.18% pro-

tein. For Jerseys, component levels were elevated to 5.17% milk fat and 3.80% protein. Milk production was maintained at baseline levels of 66.0 lb/d for Holsteins and 46.2 lb/d for Jerseys.

2. Decrease components – Production of milk fat and protein were decreased from the baseline by one standard deviation. For Holsteins, component levels were 3.36% milk fat and 2.87% protein. For Jerseys, component levels were 4.18% milk fat and 3.33% protein. Milk production was maintained at baseline levels of 66.0 lb/d for Holsteins and 46.2 lb/d for Jerseys.
3. Increase production – Production of milk was increased from the baseline by one standard deviation. Milk production was elevated to 77.1 lb/d for Holsteins and 55.6 lb/d for Jerseys. Component levels were maintained at baseline levels of 3.72% and

Table 6. Three-year average milk yield (milking cows only) and composition of Jerseys on DHIA test¹ from PA, OH, IN, WV, WI, and MI from January 2000 through December 2002.

	n	Test-day milk yield, lb/cow per d		SCC, 1000 cells/mL		n	Fat, %		True protein, %	
		Mean	SD	Mean	SD		Mean	SD	Mean	SD
January	632	44.8	9.9	302	201	614	4.9	0.5	3.7	0.2
February	618	45.5	9.8	324	230	604	4.9	0.4	3.7	0.2
March	636	46.3	9.4	325	271	621	4.8	0.5	3.6	0.2
April	651	47.6	9.3	309	217	640	4.7	0.5	3.6	0.2
May	668	48.9	8.9	295	216	656	4.5	0.5	3.5	0.2
June	635	48.0	8.9	313	198	626	4.5	0.5	3.4	0.2
July	636	47.0	8.7	325	209	626	4.4	0.4	3.4	0.2
August	616	46.1	8.9	338	211	608	4.4	0.4	3.4	0.2
September	620	45.5	8.9	341	232	609	4.5	0.5	3.5	0.2
October	644	45.0	9.2	302	198	633	4.8	0.5	3.6	0.2
November	654	44.9	9.7	309	217	646	4.8	0.5	3.7	0.2
December	690	44.8	9.6	324	216	683	4.9	0.4	3.7	0.2
All months	7700	46.2	9.4	317	219	7566	4.7	0.5	3.6	0.2

¹Data obtained from Dairy Records Management Systems, Raleigh, NC.

Table 7. Three-year average component prices in Mideast Federal Order 33 and regional feed prices¹ used to simulate income over feed cost scenarios.

Month	Fat, \$/lb	Protein, \$/lb	Other solids, \$/lb	SCCR ² , \$/cwt	PPD ³ , \$/cwt	Legume hay, \$/lb of DM	Corn silage, \$/lb of DM	Corn shelled, \$/lb of DM	Soybean meal 48%, \$/lb of DM
January	1.2369	1.9173	0.1005	0.00060	1.71000	0.0756	0.0458	0.0514	0.1089
February	1.2677	1.8561	0.0865	0.00059	1.60667	0.0756	0.0454	0.0514	0.1156
March	1.3550	1.8002	0.0717	0.00060	1.74667	0.0728	0.0419	0.0505	0.1130
April	1.4575	1.7650	0.0685	0.00061	1.77000	0.0711	0.0411	0.0505	0.1125
May	1.5159	1.8906	0.0668	0.00064	1.64667	0.0767	0.0450	0.0518	0.1162
June	1.5809	1.8699	0.0698	0.00065	1.67333	0.0739	0.0429	0.0509	0.1170
July	1.5168	2.0332	0.0739	0.00066	1.44000	0.0731	0.0429	0.0519	0.1224
August	1.5445	1.9720	0.0763	0.00066	1.66667	0.0720	0.0423	0.0562	0.1258
September	1.5752	2.0810	0.0796	0.00068	1.30333	0.0717	0.0419	0.0598	0.1243
October	1.3232	2.2177	0.0903	0.00065	1.01667	0.0709	0.0419	0.0586	0.1215
November	1.3723	1.5221	0.0962	0.00056	2.38333	0.0764	0.0457	0.0577	0.1170
December	1.4259	1.5889	0.0977	0.00058	1.67000	0.0778	0.0461	0.0583	0.1187

¹Feed prices were obtained from a monthly summary of Pennsylvania feed prices published on the Penn State Team Dairy Web site (<http://www.das.psu.edu/teamdairy/>).

²SCCR = Somatic cell count adjustment rate.

³PPD = Producer price differential.

4.67% milk fat and 3.03% and 3.57% protein for Holsteins and Jerseys, respectively.

- Decrease production – Production of milk was decreased from the baseline by one standard deviation. Milk production was reduced to 54.8 lb/d for Holsteins and 36.8 lb/d for Jerseys. Component levels were maintained at baseline levels of 3.72% and 4.67% milk fat and 3.03% and 3.57% protein for Holsteins and Jerseys, respectively.

Milk revenues and feed requirements were estimated for each scenario (Table 8) as described previously. The results of this simulation suggest that increasing milk fat and protein percentages for the Holstein herd by one standard deviation increased IOFC by \$16,096, or 7.7% of the baseline IOFC. On the other hand, a reduction of milk fat and protein by one standard deviation decreased IOFC for the Holstein herd by \$15,988, or 7.7% of the baseline IOFC. Increasing milk yield by one standard deviation increased IOFC by \$40,887, or 19.6% of the baseline IOFC. Decreasing milk yield by the same amount reduced IOFC by \$42,583, or 20.4% of the baseline IOFC. Results for the Jersey herd were similar. An increase in milk fat and protein percentages by one standard deviation resulted in \$16,229 more IOFC (9.2% of baseline IOFC); a one standard deviation decrease reduced IOFC by \$15,808 (–8.9% of baseline IOFC). Increasing milk production by one standard deviation resulted in \$42,266 more IOFC (23.9% of baseline IOFC), while reducing production caused a \$41,425 drop in IOFC (–23.4% of baseline IOFC).

Feed costs in this simulation were calculated with limited ingredients for specific combinations of milk

yield and composition and ration changes accounted for alterations in milk fat and protein simultaneously. When attempting to change herd production of milk fat and protein, ration changes to increase milk protein are likely to be more expensive than changes to increase milk fat.

CONCLUSIONS

Analysis of the USDA federal order data indicates that milk component and SCC levels are highly seasonal. The standard deviation for SCC is large relative to the mean, implying opportunities for producers to capture higher quality premiums (or avoid quality deductions) by taking management steps to improve udder health. These data also indicate that 37.8 and 35.7% of all herds in the order experienced short-term depressions of milk fat and/or protein, respectively. In addition, 17.5% of herds had a 1- to 3-mo depression of both milk fat and protein, and 36.4% of herds had a short-term problem with high SCC. These herds lost revenue as a result.

The simulation developed in this study for representative Holstein and Jersey herds in Pennsylvania quantified the amount of money lost by producing milk with below average components. Producing milk at one standard deviation below the mean for both milk fat and protein resulted in a loss in IOFC of 7.7% for the Holstein herd and 8.9% for the Jersey herd.

Nutritional changes can be expected to alter milk fat by about 1 percentage point, whereas changes in milk protein are limited to 0.1 to 0.3 percentage points. Thus, for producers at or below average, modifications to ra-

Table 8. Annual production, gross revenue, feed cost, and income over feed cost for various Holstein and Jersey scenarios.

Scenario description	Milk/cow lb per d	Fat %	Protein %	Annual production			Gross revenue		Feed cost		Income over feed cost		
				Milk	Fat	Protein	\$/cwt	\$/yr	\$/cwt	\$/yr	\$/cwt	\$/yr	
Holstein													
Baseline ¹	65.96	3.72	3.03	2,407,172	89,591	72,893	\$13.12	\$315,853	\$4.47	\$107,514	\$8.65	\$208,339	
Increase components ²	65.96	4.09	3.18	2,407,172	98,354	76,654	\$13.94	\$335,449	\$4.61	\$111,014	\$9.32	\$224,435	
Decrease components ³	65.96	3.36	2.87	2,407,172	80,827	69,132	\$12.31	\$296,257	\$4.32	\$103,906	\$7.99	\$192,351	
Increase production ²	77.08	3.72	3.03	2,807,135	104,477	85,004	\$13.12	\$368,333	\$4.24	\$119,107	\$8.88	\$249,226	
Decrease production ³	54.84	3.72	3.03	2,007,209	74,705	60,781	\$13.12	\$263,372	\$4.86	\$97,617	\$8.26	\$165,756	
Jersey													
Baseline ¹	46.22	4.67	3.57	1,686,882	78,810	60,139	\$15.49	\$261,323	\$4.99	\$84,205	\$10.50	\$177,118	
Increase components ²	46.22	5.17	3.80	1,686,882	87,160	64,101	\$16.64	\$280,704	\$5.18	\$87,357	\$11.46	\$193,347	
Decrease components ³	46.22	4.18	3.33	1,686,882	70,461	56,177	\$14.34	\$241,942	\$4.78	\$80,632	\$9.56	\$161,310	
Increase production ²	55.60	4.67	3.57	2,025,420	94,627	72,208	\$15.49	\$313,768	\$4.66	\$94,383	\$10.83	\$219,384	
Decrease production ³	36.84	4.67	3.57	1,348,344	62,994	48,070	\$15.49	\$208,879	\$5.43	\$73,186	\$10.06	\$135,693	

¹Baseline scenarios assume 100 cows with production and components at the mean of the DHIA data obtained from Dairy Records Management Systems, Raleigh, NC.

²Increase scenarios assume 100 cows with production or components increased one standard deviation above the mean.

³Decrease scenarios assume 100 cows with production or components decreased one standard deviation below the mean.

tions and feeding management could be used to improve production of fat and protein by one standard deviation. Ensuring that rations provide adequate energy and protein and balanced amounts of rapidly fermentable carbohydrate and effective fiber is the first step. Additionally, avoiding high levels of supplemental unsaturated fats and slug feeding of concentrates can help to increase both fat and protein in milk.

Management factors contribute about 45% of the variation in milk composition, and genetics explain 55% (Van Tassell et al., 1999). However, effects of changes in management practices are seen shortly after their implementation; genetic selection is a long-term approach to improving milk composition.

Milk yield is positively correlated to yield of milk fat and protein; however, milk yield is negatively correlated to milk fat and protein percentage (Welper and Freeman, 1992). Heritabilities for milk yield range from 0.32 to 0.40 for Holsteins and 0.38 to 0.48 for Jerseys (Van Tassell et al., 1999). Heritabilities for milk fat and protein yield range from 0.33 to 0.36 and 0.25 to 0.36 for Holsteins and 0.31 to 0.37 and 0.32 to 0.42 for Jerseys (Van Tassell et al., 1999). Given these relatively high heritability rates, producers could benefit from considering component production in their selection criteria, particularly if fat and protein production are below average.

On a herd level, more rapid genetic change could be achieved by purchasing cows with higher component production, including adding Jersey cows to a Holstein herd, adding Holsteins to a Jersey herd, or by crossbreeding. This study shows there is an economic balance between greater gains in milk production per cow and higher component levels in improving IOFC. With any of the above strategies, it is important to remember that total volume of components resulted in the highest IOFC. In the case of adding Jerseys to a Holstein herd, the addition of too many cows with milk production lower than the current herd average could negate any gains in higher component percentages. The reverse would be true for adding Holsteins to a Jersey herd to increase total milk volume; adding too many cows with low component percentages might offset the benefit of greater milk production. Similarly, a crossbreeding scheme that reduces milk production could negatively influence revenues. A more detailed analysis of the factors affecting an individual herd would be required to determine the levels of milk, milk fat, and protein that would result in the greatest increase in IOFC. Changes in the breed structure of a herd could also generate additional costs related to modifications of facilities and introduce new challenges for herd management that are not considered in a simple calculation of IOFC.

In all of the scenarios presented above, the most important factor affecting IOFC was the total amount of milk fat and protein produced. Although milk price is determined in part by the percentage of each component, it is the volume of milk components sold each month that results in higher levels of IOFC. Regardless of breed, increasing milk volume improved IOFC more than increasing component levels. Thus, a logical management strategy would be to set a target level for milk fat, protein, and daily milk production for each month of the year based on herd genetics, past performance, seasonality, and goals. If component levels or daily milk production drop below the target level, corrective action should be implemented quickly to minimize IOFC losses.

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