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THE EVALUATION OF THE IMPACT OF INCOME OVER FEED COST, FEED MANAGEMENT AND DAIRY ADVISORY TEAMS ON DAIRY FARM SUCCESS

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Marianne Helen Buza

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The thesis of Marianne Helen Buza was reviewed and approved* by the following:

Lisa A. Holden
Associate Professor of Dairy Science
Thesis Advisor

Chad D. Dechow
Associate Professor of Dairy Cattle Genetics

James W. Dunn
Professor of Agricultural Economics

Terry D. Etherton
Distinguished Professor of Animal Nutrition
Head of the Department of Animal Science

*Signatures are on file in the Graduate School

ABSTRACT

Today's dairy industry is complex and continuously improving. A producer's management of the operation is the most important item on the road to profitability. Since dairy farms are so complex, producers must master managing all of the areas of the business in order to achieve maximum profitability and productivity. Feed is the largest expense in producing milk. This makes proper management of feeding and nutrition pivotal to both profitability and productivity. Management of profit margins is necessary in order to make the best decisions for the dairy business. The effective use of different management tools, such as income over feed cost and dairy advisory teams, can lead to better profitability and productivity by helping dairy producers make the best management decisions. This thesis will discuss three studies that investigated 1) milk income and feed cost profit margins 2) current feed management on dairy farms, with an interest in by-product feed management 3) and the use of dairy advisory teams to improve overall farm success.

With volatility in feed and milk markets, income over feed cost (IOFC) is a more advantageous measure of profit than simply feed cost per cow. The Pennsylvania State Extension Dairy Team IOFC tool was used to collect data from 95 Pennsylvania lactating dairy cow herds from 2009-2012 and to determine IOFC per cow per day. The data collected included average milk yield, milk income, purchased feed cost, ration ingredients, ingredient cost per ton, and amount of each ingredient fed. Feed costs for home-raised feeds for each ration were based on market values rather than on actual on-farm cost. Actual costs were used for purchased feed for

each ration. Mean lactating herd size was 170 ±10.5 cows, and daily milk yield per cow was 31.7 kg ± 0.19kg. Mean IOFC was $7.71 ±$1.01 cost per cow ranging from -$0.33 in March, 2009 to $16.60 in September, 2011. Data was analyzed using a one-way ANOVA in SPSS. Values were grouped by quartiles and analyzed with all years combined as well as by individual year. Purchased feed cost per cow per day averaged $3.16 ± $1.07 for 2009-2012. For 2009-2012 combined, milk yield and IOFC did not differ with purchased feed cost. Intermediate levels (quartiles 2 and 3) of forage cost per cow per day between $1.45 and $1.97 per cow per day resulted in the greatest average IOFC of $8.19 and the greatest average milk yield of 32.3kg. Total feed costs in the fourth quartile ($6.27 or more per cow per day) resulted in the highest IOFC. Thus, minimizing feed cost per cow per day did not maximize IOFC. In 2010, the IOFC was highest at $8.09 for dairies that fed one or more commodity by-product feeds.

Due to tight profit margins and volatility in feed costs, many producers incorporate by-product feeds into their rations. This study used an electronic survey to gather information about feeding management and the use of by-product feeds in rations for Pennsylvania dairy farms in 2013. The survey was sent to 200 dairy farms via email, and 41 surveys were completed. The survey was first sent out in November 2013 and the last response was received in April 2014. All data were collected for the month of September 2013. Survey responses showed that most (97.6%) of the responding Pennsylvania (PA) dairy producers fed a total mixed ration (TMR). Over half (58.5%) of the producers fed a 60:40 forage to concentrate ratio for the ration. Distillers grains and brewer’s grains and yeasts were the most commonly used by-product feeds. Producers analyzed dry matter weekly or biweekly (60.9 %) or when switching feeds (34.1 %). Most TMR and forage nutrient testing was done when switching feeds, except for by-product

commodity feeds, which most producers never nutrient tested. Most dairy producers used PC Dart as a management tool.

Dairy producers continuously seek ways to improve their farm, and many choose to form a dairy advisory team (DAT) to improve management. The objectives were: (1) to compare key measures before and after the team in order to determine if the use of a DAT was effective and (2) to compare a group of 24 herds with a DAT to Pennsylvania (PA) averages for key measures. Teams were formed between May 2008 through January 2013. The range for herd size was 32-608 with a standard deviation of ± 13.96 cows. Herd size, milk yield, somatic cell score (SCS), peak milk yield, age at first calving (AFC), days in milk (DIM), pregnancy rate and cull and mortality rates were key measures analyzed. The changes in key measures, after using DAT for at least one year, were analyzed using a general liner model and contrasts. After DAT use for one year, herds had significantly ($P<0.05$) higher percent of herd with SCS 1-3 of 76.92 vs. 73.79 and higher peak milk in the third plus lactation with 45.60 vs. 43.30 kg. After DAT use for more than one year, these herds had significantly ($P<0.05$) higher milk yields of 33.56 vs. 31.13 kg. The DAT also had a lower ($P<0.05$) AFC of 24.45 vs. 25.50 months and higher percent of herd with SCS 1-3 of 79.33 vs. 73.79 % after the team was in place for longer than a year. Herds using a DAT for more than one year had lower days in milk (DIM) of 173 vs. 187 and higher peak milk in the third plus lactation of 47.4 vs. 43.3 kg. The DAT herds' January Dairy Herd Improvement Association (DHIA) test data were compared to Dairy Metric's PA average for January 2014 using a one-sample t-test. Farms with a DAT had significantly ($P<0.05$) higher milk yield of 33.9 vs. 31.9kg and peak milk yield for lactation 1 with 36.1 vs. 33.9kg . Herds

with DAT had significantly (P<0.001) lower AFC of 24.4 vs. 25.6 months and higher percentage of herd with SCS 1-3 79.85 vs. 73.4%.

In summary, the management of a dairy farm is complex business. Profit margins, feeding management and continuously making improvements on the farm are all part of dairy farm management. Results of these studies indicated that intermediate levels of forage cost and higher levels of total feed cost per cow per day resulted in both higher milk yield and higher IOFC. Dairy producers were successful at feed management, but increasing the amount of nutrient testing on by-product feeds and use of dairy data analysis tools may increase their success. These studies also showed that the use of DAT led to greater milk yield, lower AFC and better SCS. Herds with DAT had higher milk yield, lower AFC and better SCS compared to PA averages. Use of a DAT was beneficial to dairy farms. Many management practices exist that can be applied to dairy farms to increase both production and profitability.

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Chapter 1
LITERATURE REVIEW

Introduction

The success of a dairy farm operation depends on a number of different processes. The goal of dairy producers, like all business ownerss, is to achieve maximum production and profitability. To be successful, dairy producers must manage all of the various elements of the farm operation. Since feed is generally the largest expense, the proper management of feeding and nutrition is key to both cost effectiveness and yield of milk. Management of both income and expenses, along with the overall profit margin, is necessary in order to best manage for changes that impact the dairy business. The use of different tools, such as monitoring income over feed cost (IOFC) and dairy advisory teams, may lead to better production and profitability by helping dairy owners to make better management decisions.

This thesis contains research that has been conducted in several key areas of dairy farm management including: 1) the use of income over feed cost (IOFC) as a profit margin management tool; 2) current producer management of by-product feeds use and; 3) use of dairy advisory teams (DAT) as a management decision making tool. The literature reveals gaps in the information about the success of these management tools on dairy farms.

The Use of Income Over Feed Cost in Dairy Farm Management

Dairy producers struggle to predict their profit margins because of continuous fluctuations in milk and feed price creating a variable income. This is complicated further by changing feed, seed, fuel and fertilizer prices (CME Group Inc, 2013). In order to help predict profitability, producers can monitor profit margins, milk income and feed costs. Milk production is often monitored because higher milk yield equates to higher milk income. However monitoring gross milk income per cow alone does not provide a good estimate of cash flow or profitability, especially when feed costs are high. The IOFC is the measure of what remains of the milk income after subtracting the feed cost of the lactating cows on a per cow per day basis or on a per hundredweight basis. Income over feed cost can be used to evaluate nutrition and pasture management as well. Monitoring IOFC monthly can determine if feed costs are appropriate for the current milk production or if the ration and feed management strategies are currently successful (Maulfair et al., 2011). In 2010, Wolf showed that income over feed cost (IOFC) could be used to monitor profit by including gross milk income and feed cost (Wolf, 2010). In grazing herds, IOFC was utilized as a measure of how well feeding strategies were being implemented (Vibart et al., 2012).

Increasing the quality of forage or the combinations of forages used in a diet can lead to increased IOFC and milk yield. Baars (1998) found that farms were over supplementing concentrates to grazing herds using IOFC. The farms were feeding more concentrate than needed and had very low IOFC because of not using enough of the good quality pasture already available. In a sensitivity analysis with dual purpose cows in caostal Mexico, Absalón-Medina et al. used the Cornell net carbohydrate and protein system and IOFC to measure improvements in milk production over three lactation with the use of concentrate supplementation, high quality grass or grass supplemented with legume forages. It was found that IOFC was $1,195.00/animal lifetime at the baseline where animal lifetime was equal to three lactations. Adding the use of concentrates in the diet increased IOFC from $1,195.00 to $1,779.00/animal lifetime. Diets that relied on harvested grass and with grass and forage legume increased the IOFC baseline from $2061.00/animal lifetime to $2,326.00/animal lifetime respectively, finding that the addition of forage legumes to grass would increase IOFC. This study used a baseline milk yield of 6,435 kg/animal lifetime, with the diets of concentrate supplementation, harvested grasses and grasses with legume forages increasing kg/animal lifetime milk yield from 6,435 to 8,685, 10,079, and 11,223 respectively (Absalón-Medina et al., 2011). Good quality forages increased IOFC and milk yield, however good quality forages did not always result in the same increased level of milk production and varied with each individual cow (Allen, 1996).

Feed cost is a key part of the profit margin because feed is the largest expense. Feed quality also impacts the milk production and profitability of a dairy enterprise. The impact of feed cost on IOFC has had mixed results over the years. Baars (1998) fed higher cost concentrates that resulted in both higher milk production and a higher IOFC. In contrast, Vibart et al. (2012) found that stocking density affected IOFC, but feed cost and pasture utilization did not impact IOFC. Miller et al. (1971) found that high forage prices reduced IOFC. Grasser et al. (1995) found the use of by-product feeds (whole cotton seed, wet brewers grain, wet citrus pulp, wet corn gluten feed, corn gluten meal, dried beet pulp, pressed citrus pulp, almond hulls and rice bran) decreased total feed costs, showing the value of the use of by-product feeds as a commodity purchased feed. In a simulated model, feed prices did not impact profit on dairy farms (Congleton and King, 1983). Smith (1976) used two models with milk price at $7.00/cwt and $9.00/cwt to show that IOFC was the highest when concentrate costs were low, but forage cost had no impact on IOFC. The IOFC remained constant when concentrate prices and forage prices were high, but IOFC decreased when concentrate prices were high and forage prices were low (Smith 1976). Brown and White (1973) used Dairy Herd Improvement Association (DHIA) records of Guernsey, Holstein and Jersey herds to create a model to predict variation in IOFC. This model showed increased concentrate costs significantly reduced income, but concentrate feeding also increase milk production. In the Holstein model, one kg of concentrate feed increased milk yield by 0.74 kg/day. The regression analysis of milk yield and concentrate price was positive because of the increased milk yield when feeding higher quality concentrates. In the regression analysis of IOFC, this study showed five variables (milk price, milk yield, concentrate feeding, concentrate price and other feed costs) that highly influenced IOFC. If Holstein milk price increased by $1.00/45.5 kg then IOFC increased to $127.42/cwt. If Holstein milk yield increased 1kg /cow then IOFC increased by $0.096/cow (Brown and White, 1972). Since both milk price and feed cost impacted IOFC, the variation in the research results with this group of studies was likely the result of the differences in milk price and feed prices over the years.

Organic dairy farms had a more consistent milk price than conventional dairy farms however, feed cost was less consistent. A study on organic dairies at the University of New Hampshire and University of Maine showed that in the organic feeding system, the use of pellets and corn silage had a significantly higher cost when compared to grass at the University of New

Hampshire, but not at the University of Maine. A bootstrap analysis showed the grass silage (the lower cost of feed) had the highest IOFC, and the corn silage (the higher cost feed) had the lowest IOFC (Marston et al., 2011).

With volatility in milk prices, producers often search for ways to stabilize their incomes. The livestock gross margin (LGM) for the dairy cattle insurance program was developed to help protect producers from large losses in a volatile market (CME Group Inc, 2013). Profit margin risk management in part can be done by monitoring IOFC (Bozic et al., 2012). Research has been conducted to find the optimal LGM coverage and the best incorporation into farm management decisions (Bozic et al., 2012, Valvekar et al., 2011, Valvekar et. al., 2010). Farms can improve risk management by monitoring IOFC when using the LGM insurance program because knowing IOFC can help the farm manager to choose the appropriate level of margin to insure, decreasing volatility in profitability.

By-product Feeds and Feed Management

The proper nutrition of dairy cows is a key for the success of a dairy operation. Without the proper nutrient composition in a diet, milk production will decrease. However many feeds vary in nutrient composition, and diets are often formulated without a laboratory analysis of the feeds. In this case, the diet is formulated based on book values for nutrient composition. This type of diet formulation method can lead to less than optimal milk production and higher feed costs. Since feed is the largest expense, creating the optimal ration for efficient milk production is critical for the success of a dairy operation. Feed variably in a dairy ration can come from storage and handling of feed, processing of the feed and nutrient composition of the various feeds in the ration. Ration variability and the impact on productivity have been investigated over the years. Kertz (1998) analyzed the variability in nutrient composition in forages, grains, by-products and the total mixed ration (TMR). Kertz found that the crude protein (CP) had a high coefficient of variation at 15-30% within one type of forage. There was also a large variability in dry matter (DM) content, most noted in the silages. The grains analyzed showed little to no variability in nutrient content. Kertz found that for dairy cows, variability in the TMR occurred due to changes in mixing and weighing of feeds as well as due to the nutrient content of the feeds and the sampling methods used. Pursuing the need to find out how much the computer formulated ration varied from what the cows were being fed, Rossow and Aly (2013), used five California dairies with 4 different pens on each dairy to discover how much the nutrients varied. These researchers found that milk yield had high coefficients of variation at 16 to 47%, but milk fat and protein had lower coefficients of variation. Fat, lignin and ash had the highest coefficients of variation for the lactating pen rations on the five dairies. Lignin variability in the rations had the highest correlation with milk yield variability (Rossow and Aly, 2013). Weiss et al. (2013) conducted three experiments with ration variability and the impact on feed intake and milk yield. The first was variation of long chain fatty-acids from the addition of corn oil, which reduced intake and milk yield. The second was variation of dry matter in silage, which had no impact on the cows, as long as enough feed was given. The third study examined variation in forage quality, which did not impact average milk yield or intake. This suggests that dairy cattle can adapt to some variation in the diet on a day-to-day basis. Weiss and St-Pierre, (2009) suggested several solutions for managing nutrient variation. First, finding and selecting feeds with low variability can help reduce variation in nutrient content of the overall TMR. Second, by including many ingredients in a ration, any variability in nutrient content of a single ingredient will have less impact on the overall ration. Third, purchasing commodity feeds from one source rather than multiple sources can help to decrease variation in nutrient content, and, last, training employees to mix the feed properly and having as few as possible people feeding the cows may also reduce variability in the TMR (Weiss and St-Pierre, 2009).

Many industries create by-products that have been successfully used as feeds for livestock. The use of these by-product feeds has been an excellent way to decrease feed cost on farms (Bernard, 2012). Disposal of by-products can have a negative environmental impact and be costly for the industry that produces them. However, the use of these by-products as livestock feeds has the dual benefits of reducing negative impacts on the environment and generating revenue. Distillers grain generated by the ethanol industry is one example of a by-product feed that can be utilized by cattle rather than going to a landfill. The process of extracting ethanol from grains creates a useful high fiber, high protein, by-product feed that can be sold to farms and utilized by animals (De Groot, 2007). The major challenge with using by-product feeds is their variable nutrient content. Using a feedstuff that is variable can create a diet that is not consistent with what a nutritionist planned, leading to a decrease in milk yield (Weiss and St-Pierre, 2009). Since the use of by-product feeds is desirable for both economic and environmental reasons, the dairy industry is finding ways to manage the variability in the ration caused by by-product feeds.

Farms feed by-product feeds because they are generally less expensive than conventional feedstuffs. Published values of nutrient content of feeds, including by-product feeds, are available; however when a diet uses published values for a by-product feed, the ration may be improperly balanced because by-product feed nutrient content varies from the published values. Belyea et al. (1989) analyzed nutrient content of the following by-product feeds: whole cotton seed, soybean hulls, rice bran, corn gluten feed, and dried distillers grain. When the energy content of these five by-product feeds was compared to four published sources, significant differences were found. This study recommended that by-product feeds always be sent for nutrient testing before being used in a ration (Belyea et al., 1989). Arosemena et al. (1995) compared beet pulp, rice bran, almond hulls, citrus pulp, bakery waste, wheat mill run, brewers grain, distillers grain and soy hulls to the 1989 National Research Council Nutritional Requirements for Dairy Cattle (NRC) values for the nutrient content of these by-product feeds. Most of these select by-product feeds varied by at least 20% from the listed NRC values. Beet pulp, rice bran, almond hulls, citrus pulp and bakery waste varied by more than 20% from the NRC values compared to wheat mill run, brewers grain, distillers grain and soy hulls which varied less than 20%. The second part of the study by Arosemena et al. created two theoretical diets to analyze by-product variability on the overall ration. Diet 1 contained 27% by-product feeds and diet 2 contained 50% by-product feeds. As by-product feeds increased from diet 1 to diet 2, the overall variation became greater, but the impact on the ration appeared small (Arosemena et al., 1995). DePeters et al. (2000) reported more data on the nutrient composition of by-product feeds in order to increase the use of by-product feeds. Seventeen (almond hulls, dried and wet beet pulp, dried and wet brewers grains, canola meal, wet citrus pulp, wet corn gluten feed, whole cotton seed, cracked cottonseed, dry distillers grain, hominy feed, corn, molasses, liquid cane, rice bran, safflower meal, soybean hulls, and wheat mill run) commonly used by-product feeds' nutritional composition were analyzed. The study compared variability within each by-product feed and different parts of the nutrient composition. The analysis of nutrient composition of by-product feeds used in dairy rations was recommended, since the variability of these products had not been analyzed in lactating cows (DePeters et al., 2000). Belyea et al. (2004) investigated if variability within the by-product feed, distillers grain, came from the variability with the corn that distillers grain is made from, or if it is from the ethanol production process. They found that the coefficients of variation from the nutrient content of corn were similar to those of distillers grains. Also no significant correlations were found among the nutrient content of corn and distillers grains. This led Belyea et al. to assume that variability in nutrient content of distillers grains was not caused by the variability in the corn used to make it.

Research has shown that by-product feeds vary in their nutrient content. Learning how to manage this variability remains a challenge for the dairy industry. However, with the exception of distillers grains, many of these by-products have not been analyzed with lactating cow rations to see how the variability would impact milk yield.

The digestibility of by-product feeds may be as variable as the nutrient composition. DePeters et al. (1997) investigated the digestibility and chemical composition of beet pulp, rice bran, almond hulls, citrus pulp, bakery waste, wheat mill run, brewers grain, distillers grain and soy hulls. Each was taken from three different sources. Samples were analyzed in both a rumen cannulated cow and with chemical analyses. Significant nutrient variability was found between the sources of the by-product feeds with the chemical analysis. A difference in fiber-bound crude protein was found between sources of by-product feeds, along with a difference in digestion time (DePeters et al., 1997). Kleinschmit et al. (2007), used two rumen cannulated lactating cows to investigate the crude protein and amino acid degradability of five sources of dried distillers grains, one source of wet distillers grain and one source of soybean meal. The rumen undegradable protein (RUP) for soybean meal was 46.4% which was lower than the wet distillers grain RUP at 53.6%. The dried distillers grain RUP ranged from 60.3 to 71.7%. The intestinal digestibility was also greatest for the soybean meal, with dried distillers grain ranging from 59.2 to 76.8% and wet distillers grain at 65.8% (Kleinschmit et al., 2007). To manage the variably in both nutrient content and digestibility, by-product feeds should be analyzed when a new source of feed is being added to the ration, and the ration should be re-balanced for the new composition.

Adding some by-product feeds to a ration increased milk yield or feed intake. Hall and Chase (2014) replaced corn grain and soybean feeds with wheat straw, sugar beet pulp, pelleted corn gluten feed, distillers grain, whole cotton seed and cane molasses-whey blend in diets for lactating cows. These animals maintained fat and protein corrected milk. With the addition of wheat straw, intake of dry matter and crude protein linearly increased, along with time spent ruminating and eating. Hollmann et al. (2011) used a meta-analysis of corn distillers grains from a database of 44 treatments and found that the milk yield increased with the concentrations of corn distillers grain until this peaked at 21% corn distillers grain with an increase of 1.2kg /cow/day in milk yield. The use of by-product feeds can lower both feed costs and increase milk income.

As by-product feeds were used in more rations, Grasser et al. (1995) wanted to assess the economic importance of by-product feeds. Almond hulls, dried beet pulp, wet brewers grain, wet citrus pulp, pressed citrus pulp, wet corn gluten feed, corn gluten meal, whole cotton seeds and rice bran were analyzed for crude protein and net energy for lactation (NE_L). The milk production was calculated using crude protein and $NE_{L.}$ Data was collected from surveys of food processing plants, producers, state publications, nutritionists and feed brokers. As feed prices changed, by-product feeds were frequently the most profitable choice for a ration. This depended on the market and the ration, like so many other feed costs (Grasser et al., 1995). The knowledge of when it is most profitable to use by-products in dairy rations is still largely dependent on current market conditions and the use of IOFC is a sound tool for decision making with using by-product feeds in a TMR.

Dairy Advisory Teams Use by Dairy Producers

The use of teams to solve problems and make decisions is a common management tool in many different industries (Palfini, 2008). For teams to be successful, they must have a meaningful and common purpose, performance goals, mutual accountability, and complementary skills (Katzenbach & Smith, 1993). For a team to work cohesively, a common purpose is essential. This builds ownership and commitment from the team members to the team and the common purpose. Performance goals are needed. Performance goals create clear objectives and accountability for the purpose of the team. In order for a group of people to become a team, they must hold themselves accountable. This creates both commitment and trust. It also gives each member the right to express their views on the team's decisions. A team's skills can be sorted into three categories, technical or functional expertise, problem-solving and decision making, and interpersonal skills. Teams must have all the required areas of expertise to be successful and meet goals (Beebe and Masterson, 2000, Heald et al., 2002, Holden and White, 2013, Katzenbach and Smith, 1993). In order to move forward, teams must be able find and identify problems or opportunities. Once this is done, teams can decide together which direction to move forward. Communication is key to the success of any team. In order to reach a common goal, good communication and constructive conflict management was necessary (Katzenbach and Smith, 1993). Team members will often disagree. To work through these disagreements good communication and interpersonal skills were needed.

In past years the dairy industry has found itself in turbulent times. This was caused by the volatility of both milk and feed prices (CME Group Inc, 2013). This volatility has caused profit margins to fluctuate and fall. Many dairy producers sought ways to improve profit margins with management changes that were within their control, unlike the price of milk and feed. Some farms chose to form a dairy advisory team (DAT). The use of a DAT or other farm advisory teams were found in dairies across the across the United States (DAIReXNET, 2012). These teams were designed to help farms that were in need of assistance or were looking to make improvements to their business. A DAT is a regular assembling of a dairy farm’s advisors. This can include veterinarians, nutritionist, bank lenders, crop experts, reproduction specialists, extension educators, herd mangers and family members. Most teams had a non-farm member who served as the coordinator and facilitator for the meetings of the DAT (Heald et al., 2002). Dairy advisory teams met regularly, but the time between meetings depended on the team and the farm’s needs (Heald et. al., 2002). Implementing a DAT is one way to target bottle necks and find solutions to problems.

Many teams will try to meet a dairy farm's set goals, for example, lowering somatic cell counts (SCC) or increasing milk yield (MY). Other goals of the team can be to improve dairy farm life and farm profitability (Weinand and Conlin, 2003). Heald et al. (2002) showed that dairy advisory teams that had long-term goals rather than only short-term goals, had better success in improving management. Some farms used the DAT to focus on increasing profit margins by improving management on the farm. Also smaller herds show more immediate progress after having a DAT (Heald et al., 2002).

Individual cases of DAT success have been recorded (Hoard's Dairyman, 2012), but the success of DAT on a large scale has many unanswered questions. Profit teams have been successful in many states, one of them being New York. The goals of teams were often to increase milk production and milk quality, reduce expenses and reduce cow loss, and stay in farming longer. Many New York teams have been successful by recommending the building of new feed bunks, improving cow comfort, increasing rolling herd averages, decreasing SCC, improving calf health, improving bedding and ventilation, assisting with finances, and building new barns (Holden and White, 2013). A DAT can be an effective tool for a producer to use in improving the overall farm. However, teams can be unfocused, leading to wasted time, inefficient meetings, and increased costs. Structure of the meetings is important for focus, preparation, and to keep everyone on the same page. To evaluate the progress of the farm's goals, data is needed. The team must hold people accountable. If a team member agrees to perform something to help reach goals, the other team members must hold that person accountable for completing that task (Holden and White, 2013). A DAT may be effective at identifying needs and changing practices on a farm. These teams also reinforce the farmer putting the practice to work by the team holding the farmer accountable. This will help the farm to focus on the goals and increase chances of success (Schwartau, 2009). Funding to operate a DAT has been available in some states. This funding can help to pay for the cost of consultant time and the cost of the meetings (http://centerfordairyexcellence.org/).

Extension programs are widely used across the world and have made improvements on farming operations. In Ireland, Lapple et al. (2012) wanted to show that extension program participation is worth the investment of the government. Lapple et al. (2012) found that farms that attend extension programs had higher gross margins, larger farms, and a higher calving rate. Weinand and Colin (2003) evaluated the success of educational diagnostic teams that transferred technology onto dairy farms. This was on-farm personal communication to help farms move toward their family goals. This evaluation used DHI data and farm interviews to identify needed changes. Participating farms tended to increase herd size and milk yield, but overall the largest improvement was an increase in quality of life reported by the farmer. Rodrigues et al. (2005) assessed the use of milk quality teams on Wisconsin dairy farms. These teams were designed to improve management practices, especially with milking efficiency and milk quality. The team leaders were veterinarians, extension educators, and other agri-professionals. The program had four monthly meetings and self-selected teams. A 29 question survey was conducted at the end of the program to analyze effectiveness of the changes. Many farmers reported an improvement in more efficient milking performance and a drop in bulk milk SCC. Farms in freestall barns adopted more of the standardized procedures and recommended practices when compared with tie-stall farms. Free stall herds received more quality premiums for milk shipped and had less estimated profit foregone.

Management Strategies for Improving Profitability and Milk Yield

When analyzing the success of any new procedure or program on farms several management measures may be used. Common measures include milk yield, milk components, somatic cell count (SCC), pregnancy rate (PR), age at first calving (AFC), peak milk, days in milk (DIM), culling rate and mortality rate. Many of these measures are tied to strong economic impacts. Often producers receive bonuses for high components and low SCC. Other measures impact the overall cost of production, such as PR and AFC. One study by Cabrera et al., (2010) focused on milk yield and was conducted as a stochastic production frontier technical efficiency analysis to determine milk yield efficiency. The input variables that significantly impacted milk yield were cow numbers, feed cost, crop cost, labor cost, livestock cost, use of bST, TMR use, milking frequency, percent family labor, and the feed/cow ratio. In analyzing milk yield as a measure of technical efficiency, Michalickova et al. (2013), found that feed cost was the only input that significantly influenced milk yield. The inefficient use feed can decrease the output level of milk. To create the most efficient output of milk yield farms in the study needed to reduce feed costs, material cost, labor costs, repair cost, depreciation, direct costs and overhead cost by, 3.7, 10, 3.3,15.8, 2.1, 2.9 and 8.5% respectively (Michalickova et al., 2013). Bailey et al. (2005) investigated the returns to farms from milk components when using multiple component pricing. This study found that components were highly impacted by season and varied by farm. Fat and protein percentage were reduced by more than one standard deviation of

0.32 and 0.19 percent respectively for 1-3 months. It was found that in component pricing, fat and protein impacted income over feed cost (IOFC) the most (Bailey et al., 2005). When investigating how much profit was lost on Irish dairy farms due to mastitis, Geary et al. (2012), used a model including milk losses, culling, testing, treatment, veterinary attention, waste milk and penalties. The study found that with an increase of bulk milk somatic cell count (BMSCC) from less than 100,000 cells/ml to more than 400,000 cells/ml, milk income would change from €148,843 to €138,573. The increase in BMSCC impacted cull cow value causing higher replacement cost, decreasing total farm income from €192,147 to €189,091.

Reproductive management is also an important component of dairy farm management. When and how quickly a cow gets pregnant can have a large impact on farm expenses. Pregnancy in dairy cattle is one management measure where it is easy to see economic gain when pregnancy rate is increased. Using a bioeconomic model, De Vries (2006), found that the average value of a new pregnancy was $278. This number increased when pregnancy was achieved earlier in the lactation and decreased if achieved later in the lactation. The average cost of pregnancy loss was $555. De Vries et al. (2010) investigated reproduction risks that led to a cow being culled. This model analyzed 727 herds from 2001-2006 and found that after the 6th lactation, cows were at high risk for being culled. The highest risk of being culled was in the first 30 days after calving and again 280 days after calving. Farms with synchronized breeding programs had a lower risk for culling for reproductive issues.

When evaluating the cost of heifer raising, Heinrichs et al. (2013) found the average cost to raise a heifer from birth to freshening was $1,808.23. Of this cost, 73% was for feed. Using a data envelopment analysis on 44 farms, nine farms were labeled as efficient. For these nine efficient farms, the average age at first calving (AFC) was 23.7 months. Age at first calving had a financial impact on dairy farms. Tozer and Heinrichs (2001) found that the reduction in AFC by one month reduced the cost of a replacement program of a 100 cow herd by $1,400.00. A cost analysis spreadsheet was created by Gabler et al. (2000) to find the cost of raising replacement heifers. The average was found to be $1124.06 for milking operations and $1019.20 for custom operations to raise a heifer. Feed cost was to 60% of the cost on milking operations and 64% on custom operations. Custom operations had a lower average AFC of 22.75 vs the 24.13 months of the milking operations. By having the lower AFC custom operation is a 17% savings over the milking operations.

Monitoring culling and mortality rates is a management tool used on many farms to identify problems and monitor potential profit loss. Understanding when to cull a cow and why she is being culled are ways to increase profits and identify possible problems. Smith et al. (1993) found it was more profitable to feed a cow for two dry periods keeping days in milk (DIM) close to 305 than to milk for 365 days and then to cull and replace. When evaluating the reasons for culling given in DHI, Pinedo et al. (2010) collected information from 2,054 herds in 38 states from 2001-2006. He found that culling rate was 25.1% and the mortality rate was 6.6%. The most common reason for culling was death followed by reproduction and injury/other. Since culling can be a large cost on dairy farms, Hadley et al., (2006) collected data from ten states from 1993-1999 to analyze why cows are being culled and which cows were most likely to be culled. Season and age have had the biggest impact on when a cow will be culled.

In summary, the management of a dairy farm is complex business. Profit margins, feeding management and continuously making improvements on the farm are all essential parts of dairy farm management. The use of IOFC is an excellent way to monitor profit margins, feed expenses and milk production. Management of the use of by-product feeds and other feeds requires many different practices. The use of a DAT will give dairy producers a useful and reliable team of consultants, as well as the continuous identifications of bottlenecks and other issues. Much information has been collected in these areas but many gaps of knowledge still exist.

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Chapter 2

Evaluating the Effect of Ration Composition on Income Over Feed Cost and Milk Yield

ABSTRACT

Feed is generally the greatest expense for milk production. With volatility in feed and milk markets, income over feed cost (IOFC) is a more advantageous measure of profit than simply feed cost per cow. The objective of this study was to evaluate the effects of ration cost and ingredient composition on IOFC and milk yield. The Pennsylvania State Extension Dairy Team IOFC tool was used to collect data from 95 Pennsylvania lactating dairy cow herds from 2009-2012 and to determine IOFC per cow per day. The data collected included average milk yield, milk income, purchased feed cost, ration ingredients, ingredient cost per ton, and amount of each ingredient fed. Feed costs for home-raised feeds for each ration were based on market values rather than on actual on-farm costs. Actual costs were used for purchased feed for each ration. Mean lactating herd size was 170 ±10.5, and daily milk yield per cow was 31.7 kg ± 0.19. Mean IOFC was $7.71 ±1.01 cost per cow ranging from -$0.33 in March, 2009 to $16.60 in September, 2011. Data was analyzed using a one-way ANOVA in SPSS. Values were grouped by quartiles and analyzed with all years combined as well as by individual year. Purchased feed

cost per cow per day averaged $3.16 ±1.07 for 2009-2012. For 2009-2012 combined, milk yield and IOFC did not differ with purchased feed cost. Intermediate levels (quartiles 2 and 3) of forage cost per cow per day between $1.45 and $1.97 per cow per day resulted in the greatest average IOFC of $8.19 and the greatest average milk yield of 32.3kg. Total feed costs in the fourth quartile ($6.27 or more per cow per day) resulted in the highest IOFC. Thus, minimizing feed cost per cow per day did not maximize IOFC. In 2010, the IOFC was highest at $8.09 for dairies that fed one or more commodity by-products. Results of the study indicated that intermediate levels of forage cost and higher levels of total feed cost per cow per day resulted in both higher milk yield and higher IOFC. This suggests that optimal ration formulation rather than least cost strategies may be key to increasing milk yield and IOFC, and that profit margin may be impacted more by quality of the feed rather than the cost.

INTRODUCTION

Income for a dairy producer can be difficult to predict because milk and feed markets are continuously changing and this is exacerbated with the ever changing prices of fuel, fertilizers and crop seeds (CME Group Inc, 2013). Thus, producers should monitor profit margins rather than milk income or feed costs to predict profitability. Milk production is often monitored because higher milk production equates to higher milk income. However monitoring gross milk income per cow alone does not provide a good estimate of cash flow or profitability, especially when feed costs are high. In 2010, Wolf showed that income over feed cost (IOFC) could be used to monitor profit by including gross milk income and feed cost (Wolf, 2010). Using IOFC accounts for the volatility in milk and feed markets giving the producer a better metric for evaluating profit margin.

Income over feed cost (IOFC) is the measure of what remains of the milk income after subtracting the feed cost of the lactating cows on a per cow per day basis or on a per hundredweight basis. Income over feed cost can be used to evaluate nutrition and pasture management as well. Profit margin risk management in part can be done by monitoring IOFC (Bozic et al., 2012). Using the Penn State IOFC tool, the amount spent on purchased feeds or the cost of home raised feeds can be evaluated against the current milk production. In grazing herds, IOFC can be utilized as a measure on how well feeding strategies are being implemented (Vibart et al.,2012). Monitoring IOFC monthly can determine if feed costs are in line for the current milk production or if ration and feed management strategies are currently successful (Maulfair et al., 2011).

With volatility in milk prices, producers examine ways to stabilize their incomes. The livestock gross margin (LGM) for the dairy cattle insurance program was developed to help protect producers from large losses in a volatile market (CME Group Inc, 2013). Research has been conducted to find the optimal LGM coverage and the best incorporation into farm management decisions (Bozic et al, 2012, Valvekar et al., 2010, 2011). Farms can improve risk management by using LGM insurance program and monitoring IOFC.

The research objective of this study was to evaluate the impact of ration composition and ration cost on both IOFC and milk yield. By evaluating ration characteristics and feed costs for herds with the highest IOFC and milk yield, the best management practices could be identified.

The use of IOFC can lead to finding the best cost ration for the lactating herd. Continuous monitoring of IOFC should be coupled with a cash flow plan to determine the particular farm's breakeven IOFC. Only then will constant monitoring of IOFC be ideally meaningful to a producer and the impact on profitability.

MATERIALS AND METHODS

Income Over Feed Cost Tool

The IOFC tool was developed by Pennsylvania State University faculty, Extension educators and staff (Ishler, personal communication). Information about the tool can be found on the Pennsylvania State University Dairy Extension Team website (http://extension.psu.edu/animals/ dairy/business-management/financial-tools/income-over-feed-cost/introduction-to-iofc). The tool is an Excel spreadsheet that is user friendly. In this tool IOFC is calculated by the following formula.

(daily average milk production lbs/cow x milk price per hundred weight/100)-total feed cost/cow

Since feed costs are constantly changing, monitoring IOFC can help dairy producers monitor margins versus just milk income or feed cost. The IOFC tool divides feed into purchased and home-raised. The IOFC can be calculated using the market values for a feed type, or the actual cost. In order to best compare across all the farms, market prices for home-raised feeds were utilized (Bailey, 2009, Ishler, 2012). This allows the use of market prices to be compared to the true cost of home-raised feeds. Often true costs for each individual home-raised feeds are unknown by the producer also leading to the use of market values for home-raised feeds. For this study all feed prices were calculated using market values from Pennsylvania State University Extension web site (extension.psu.edu/animals/dairy/business-management/feed-price-list). These prices were calculated including transportation charges and profit that could be captured selling the crops rather than using them to produce milk. This website is linked to the IOFC tool and updates the monthly market prices to each IOFC worksheet. The prices for home-raised feeds reflect the value out of the structure, but do not reflect adjustments based on dry matter, forage or feed quality (Ishler, 2012). These were updated with the tool and the web site on a monthly basis.

Data Collected

All farms in this study were located in Pennsylvania. These farms were self-selected from the farms that chose to use the IOFC tool, and completed training with the tool as part of an Extension education program. The IOFC data forms were completed by the producer and were submitted to a dairy Extension team member. The IOFC spreadsheet data included: gross milk price, average milk yield, average milk shipped, home raised and purchased feed amount, cost per ton of feed, batch weights of feed, number of lactating cows, and number of lactating nutritional cow groups. Data from the forms were used to calculate IOFC with the IOFC tool monthly on a cost/cow/day basis.

On the IOFC data form, producers reported total milk weights shipped for the month, the average pick-up weight or the average per cow per day milk weight. If the average bulk tank weight was given, the weight was divided by the number of lactating cows and the number of days in the shipment. The major variables analyzed were milk income, feed cost, milk yield (kg), IOFC, purchased feed cost, number of lactating animals, purchased feed amount (kg), total feed amount (kg), and number of lactating cow groups. All feed variables were expressed on an as fed and per cow per day basis. Each ingredient was also classified as forage, concentrate grain, concentrate mix, by-product or mineral and additive. The kilograms fed on an as-fed basis and price per ton was recorded for each feed. Only those by-products used as a commodity were included in the by-product calculations. By-products existing in pre-mixed purchased feeds were not analyzed. The analysis for by-products was divided into two groups. These groups were farms that did not use by-product commodity feeds in the lactating cow ration and farms that did use by-product commodity feeds in the lactating cow ration. Feeds that fit into more than one type of analysis were analyzed for all of the analyses that were applicable. Since by-products can often be categorized as multiple feed types, forage substitute by-products were included in the forage cost analysis and purchased feed cost analysis.

Statistical analyses

Statistical analysis was completed using one-way analysis of variance (ANOVA) tests within the SPSS program (IBM Corp, 2012). The ANOVA was conducted for total feed cost, forage cost, purchased feed cost, and inclusion of commodity by-products against milk yield and

IOFC. Variables were grouped by cost quartiles of the feed and analyzed using combined data from years 2009-2012, in addition to analysis of the individual years 2009, 2010 and 2011. No separate analysis was conducted for the year 2012 due to small sample size. The quartiles were created to have the same n of months of data in each quartile when the years were combined from 2009-2012. This created four ranges of feed cost. When the individual years were analyzed, the quartiles remained the same, despite differing n for those quartiles. A Tukey (IBM Corp, 2012) mean separation test was also used to analyze the data.

RESULTS AND DISCUSSION

Results for the 95 herds analyzed had a mean lactating herd size of 170 ± 10.55 and milk yield of 31.7 kg ± 0.19 (Table 2.1). The mean IOFC was $7.71 ± 1.01 ranging from -$0.33 in March, 2009 to $16.60 in September, 2011. The mean number of lactating groups was 1.41 ± 0.046 (Table 2.1). It should be noted that this data is from a self-selected group of farms; therefore, it is a non-random sampling. Further sampling to create a larger or more normalized distribution of either farms or milk yield may lead to slightly different results.

Purchased feed cost per cow per day averaged $3.16 ± 1.07 from 2009-2012. Milk yield and IOFC did not differ with purchased feed cost, suggesting that purchased feed cost per cow was not a key factor in high milk yield (Tables 2.2 and 2.3). This was in contrast to popularly held beliefs that high purchased feed cost will result in a lower profit margin. Data from this study showed that the amount of purchased feed had no effect on IOFC in the combined years 2009-2012 or the individual years of 2009, 2010 and 2011. This does not imply that the producer who purchases high percentages of their feed may not be at risk of considerable income loss due to market changes (CME Group Inc, 2013, United States Department of Agriculture).

Dairies that fed one or more commodity by-products had no difference in IOFC ($P >$ 0.05) for the combined years for 2009-2012. However, in 2010, IOFC was highest ($P < 0.01$) for dairies that fed one or more commodity by-products. No difference for the inclusion of commodity by-product was found for the individual years of 2009 and 2011. The inclusion of commodity by-products resulted in higher ($P < 0.001$) milk yield when analyzed from 2009-2012 and a higher ($P < 0.001$) milk yield in the individual year 2010 (Table 2.4). For 2009 and 2011, there were no differences ($P > 0.05$) in milk yield with or without by-product feeds in the ration. In a previous study, Grasser et al. (1995) found use of whole cotton seed, wet brewers grain, wet citrus pulp, wet corn gluten feed, corn gluten meal, dried beet pulp, pressed citrus pulp, almond hulls and rice bran decreased total feed costs. However, milk yield and IOFC were not analyzed in that study.

Intermediate levels of forage cost between \$1.45 and \$1.96 per cow per day resulted in the highest ($P < 0.01$) average IOFC of \$8.19 for the analysis for the combined years 2009-2012. Forage cost between \$1.45 and 1.96 per cow per day also resulted in higher IOFC in 2010 ($P <$ 0.001) and 2011 ($P < 0.05$) when the years were analyzed individually (Figure 2.1). The intermediate quartiles had the highest ($P < 0.05$) average milk yield of 32.3kg for analysis for the combined years 2009-2012. When the years were analyzed individually, 2009 forage cost quartile of \$0.78-\$1.44 resulted in lower milk yield ($P < 0.05$). In 2011, forage costs of \$1.97-\$3.82 had lower milk yield (Figure 2.2; $P < 0.05$). This suggests that optimal ration formulation was key to increasing milk yield and IOFC. While there are many factors such as genetics, reproductive efficiency and management practices that impact milk yield, and therefore IOFC, this study focused only on data related to feeds and feeding management. When a ration does not have a high enough forage cost, such as rations on the farms falling into the first quartile, there may not be enough forage in the ration or the forage being fed is of low quality. Farms with high forage cost may have excess forage in the ration. Also these farms could have high forage based diets. Diets that contain high moisture forage may have the higher forage cost because high moisture forage is more expensive and the analysis is on an as fed basis and not a dry matter basis. Forage cost has also increase because of an increased dependence on purchased forage on some farms. This is not common on Pennsylvania dairy farms but is more common in other areas of the country. A previous study supported this data, finding optimal forage to concentrates ratio using IOFC with pasture feed dairy cows (Baars, 1998). A study on dual purpose cows in costal Mexico, Absalón-Medina et al. used the Cornell net carbohydrate and protein system and IOFC to observe improvements in milk production over three lactation with the use of high quality grass or grass supplemented with legume forages. It was found that high quality forages or a combination of pasture and legume forages led to increased milk yield and IOFC when compared to the traditional use of grass and concentrate supplementation. Feeding diets utilizing grass and legume forage diets increased IOFC by $1,131 across three lactation cow lifetime and rations using high quality grass increased IOFC by $866 across three lactations cow lifetime (Absalón-Medina et al., 2011).

Total feed costs in the top quartile ($6.27 or more per cow per day) resulted in the highest (P < 0.01) IOFC for the combined years analyzed for 2009-2012. For the individual year of 2010, the top feed cost quartile also had the highest (P < 0.01) IOFC values. The individual years of 2009 and 2011 showed no difference (*P* > 0.05) in IOFC (Figure 2.3). The combined years 2009-2012 and in 2010, milk yield was the highest (*P* < 0.001) when feed costs were $6.27 or higher. The individual years of 2009 and 2011 showed no difference (*P* > 0.05) in milk yield (Figure 2.4).

Minimizing feed cost per cow per day did not result in the highest IOFC for this study. This supports the use of high quality feed to improve IOFC and milk yield rather than the use of a least cost ration. These findings are supported by Baars (1998) where feeding higher cost concentrates resulted in both higher milk production and a higher IOFC (Baars, 1998). The cost and quality of the feed can impact profit margins, making IOFC the best tool to monitor the feed quality's impact on milk yield as well as the overall cost of the ration. In contrast, Vibart et al. (2012) found that stocking density effected IOFC, but feed cost and pasture utilization did not in a simulated model. Feed prices did not impact profits on dairy farms (Congleton and King, 1983). In this study, real farm data shows feed cost can affect IOFC and milk yield making margin management important to farm success. A study on organic dairies at the University of New Hampshire and University of Maine, showed that in the organic feeding system, the use of pellets and corn silage on a commodity basis had a significantly higher cost when compared to grass silage on a commodity basis at the University of New Hampshire, but not at the University of Maine. A bootstrap analysis showed the grass silage (the lower feed cost) had the highest IOFC, and the corn silage (the higher cost feed) and had the lower IOFC. This study disagreed with the current study in that higher cost feeds have higher IOFC, however Marston et al (2011), was investigating organic dairies which likely has very different economic constraints from the current study.

CONCLUSION

Milk yield and IOFC were not impacted by the level of purchased feed cost. Inclusion of by-product feeds on a commodity basis showed increased milk production for these farms. Intermediate levels of forage costs resulted in the highest levels of both IOFC and milk yield, suggesting that IOFC needs to be monitored monthly to evaluate changes in management and rations. Higher total feed cost resulted in higher IOFC suggesting that low feed cost alone did not ensure high net margins. The IOFC can be used effectively in assessing the impact of management and ration changes on net milk margin. Income over feed cost should be used with the producers' breakeven IOFC to be effective in monitoring profitability.

Inclusion of commodity by-product feeds, intermediate levels of forage cost and higher levels of total feed cost per cow per day resulted in both higher milk yield and higher IOFC suggesting that profit margin was impacted by other factors in addition to feed cost per cow. Monitoring feed management on a regular basis and creating and maintaining the optimal ration were necessary to maintain profit margins.

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Table 2.1. Number of lactating cows, lactating cow groups, milk production, gross milk price, feed cost per cow per day, income over feed cost (IOFC) and total milk income for 95 farms from combined years 2009-2012. n=500

	Mean	Minimum	Maximum	SEM
Number of lactating cows	170	20	1475	10.5
Number of lactating cow groups	1.4	1	7	0.046
Milk Production cow/day, kg	31.52	18.19	50.57	0.153
Gross Milk Price, $/CWT	19.07	11.75	25.39	0.124
Feed Cost cow/day, $	5.63	2.92	9.20	0.044
IOFC cow/day, $	7.71	(0.33)	16.60	0.101
Milk Income cow/day, $	13.33	3.94	20.91	0.115
Purchased Feed Amount cow/day, kg*	10.55	0.83	50.80	0.91
Total Feed Amount cow/day, kg*	45.71	25.0	75.68	0.578

* On an as fed basis

Table 2.2. The analysis of variance of quartiles of purchased feed cost against income over feed cost (IOFC) of that ration for the years 2009 through 2012 together, then each year individually. n=500

	Feed cost quartiles[1]			
	$0.79-2.47	$2.48-3.13	$3.14-3.81	$3.81-7.61
Purchased feed cost 2009-2012[2]				
n	129	121	125	125
Mean IOFC, $	7.73	7.34	7.94	7.81
SEM	0.179	0.211	0.184	0.226
Purchased feed cost 2011[2]				
n	38	52	46	62
Mean IOFC, $	8.33	8.58	9.17	8.74
SEM	0.276	0.244	0.238	0.262
Purchased feed cost 2010[2]				
n	74	43	54	32
Mean IOFC, $	7.46	7.50	7.48	8.22
SEM	0.180	0.216	0.207	0.363
Purchased feed cost 2009[2]				
n	15	26	12	17
Mean IOFC, $	4.86	4.61	5.11	4.86
SEM	0.303	0.445	0.665	0.719

[1]The purchased feed costs were divided into four quartiles for when all the years were combined. The quartiles remained the same for each individual year analysis

[2]Purchased feed cost resulted in no significant difference (*P* >0.05) in IOFC.

Table 2.3 The analysis of variance of quartiles of purchased feed cost against milk yield of that ration for the years 2009 through 2012 together, then each year individually. n=500

Feed cost quartiles[1]				
	$0.79-2.47	$2.48-3.13	$3.14-3.81	$3.81-7.61
Purchased feed cost 2009-2012[2]				
n	129	121	125	125
Mean milk yield, kg	31.12	31.40	31.93	32.25
SEM	0.742	0.846	0.704	0.972
Purchased feed cost 2011[2]				
n	38	52	46	62
Mean milk yield, kg	31.32	32.10	32.42	31.35
SEM	1.095	1.076	0.890	1.222
Purchased feed cost 2010[2]				
n	74	43	54	32
Mean milk yield, kg	30.91	31.02	31.23	34.44
SEM	1.111	1.082	1.049	2.250
Purchased feed cost 2009[2]				
n	15	26	12	17
Mean milk yield, kg	31.09	30.63	30.48	30.93
SEM	1.533	2.758	2.912	2.964

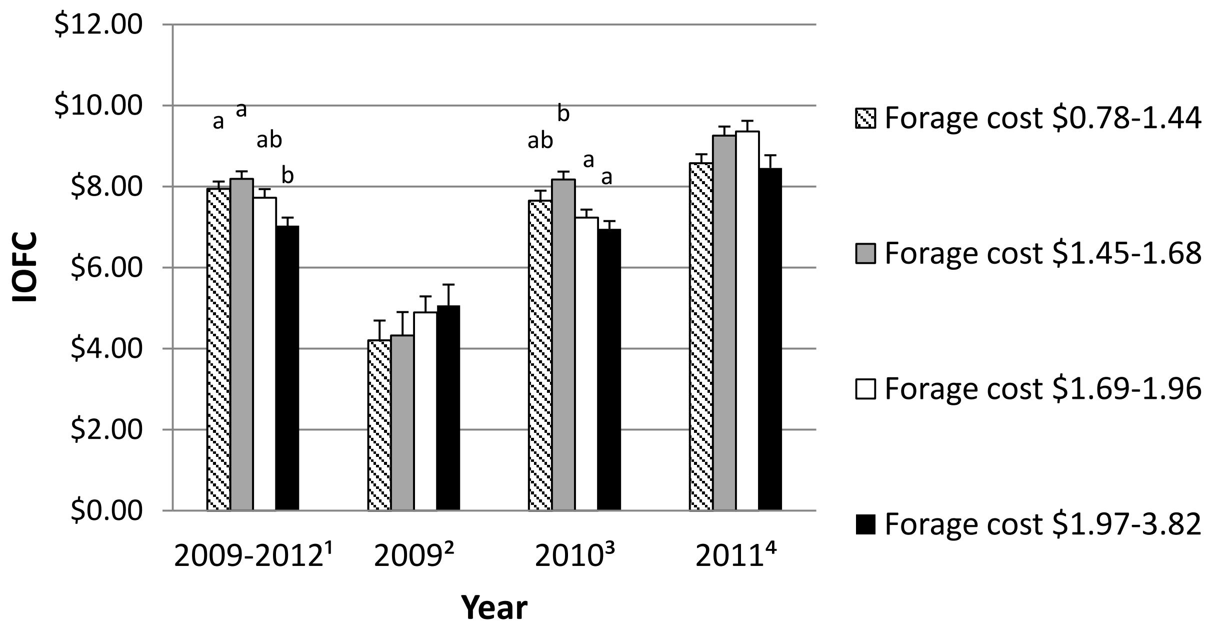
[1]The purchased feed costs were divided into four quartiles for when all the years were combined. The quartiles remained the same for each individual year analysis.
[2]Purchased feed cost resulted in no significant difference ($P > 0.05$) in milk yield.

Table 2.4. The inclusion of one or more by-product on a commodity basis in a ration and the effect on milk yield.

	No by-product	One or more by product
Inclusion of by-product 2009-2012*		
n	332	168
Mean milk yield, kg	31.21	32.59
SEM	0.511	0.668
Inclusion of by-product 2009		
n	38	31
Mean milk yield, kg	30.29	31.35
SEM	2.125	1.658
Inclusion of by-product 2010*		
n	147	56
Mean milk yield, kg	30.97	33.16
SEM	0.741	1.369
Inclusion of by-product 2011		
n	128	70
Mean milk yield, kg	31.48	32.36
SEM	0.751	0.776

* significant at the 0.001 level
n=500
By-products used in pre-mixed feeds were not included in this analysis.

Figure 2.1. Ration forage cost ANOVA by cost quartiles for the impact of forage cost on income over feed cost (IOFC) for the combined years of 2009-2012 and the individual years of 2009, 2010, and 2011.



[ab] Means with different superscripts differ by P<.05.

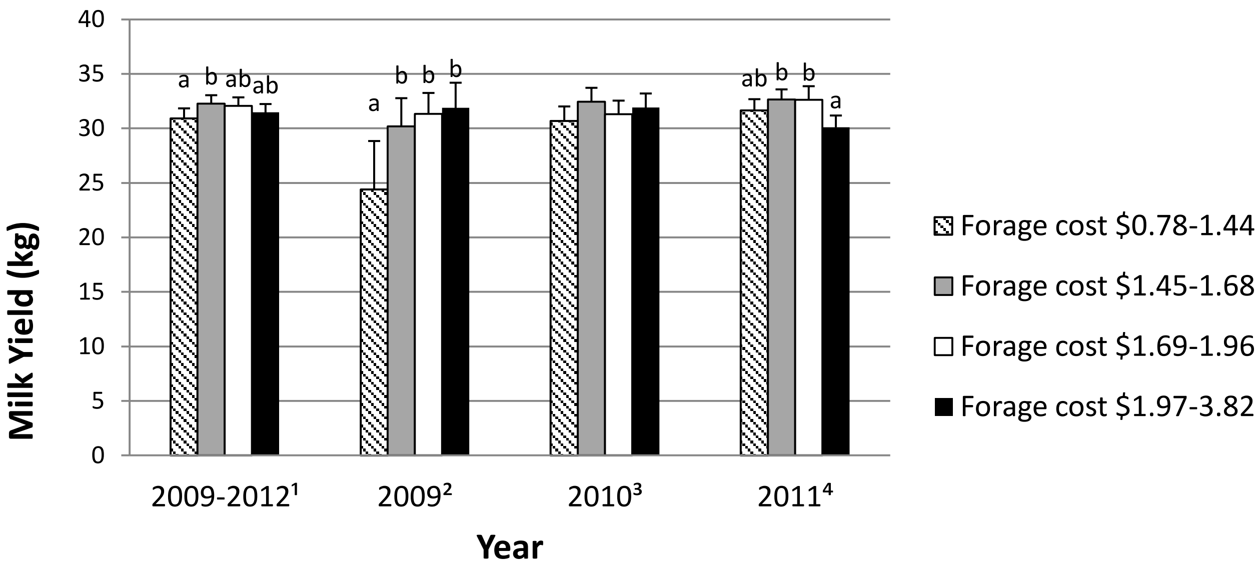
[1]For 2009- 2012 n values in order of increasing quartile ranges were 127, 124,124, and 125. Forage cost between $1.45-1.68 had significantly higher IOFC when compared to the forage costs between $1.97-3.82.

[2]In 2009 the n values in order of increasing quartile ranges were 6, 11, 25 and 28. There was no significant difference between quartiles.

[3]In 2010 the n values in order of increasing quartile ranges were 62, 62, 41, and 38. The test for normality was non-normal data with a p= 0.019. The ANOVA resulted in the forage cost of $1.45-1.68 having a higher IOFC when compared to forage costs of $1.69-3.82.

[4]In 2011 the n values in order of increasing quartile ranges were 55, 47, 51, and 45. This resulted in an ANOVA result of P=0.024, but the Tukey analysis resulted in no significant difference, P=0.071.

Figure 2.2. Ration forage cost ANOVA by cost quartiles for the impact of forage cost on milk yield for the combined years of 2009-2012 and the individual years of 2009, 2010, and 2011.



[ab] Means with different superscripts differ by P<.05.

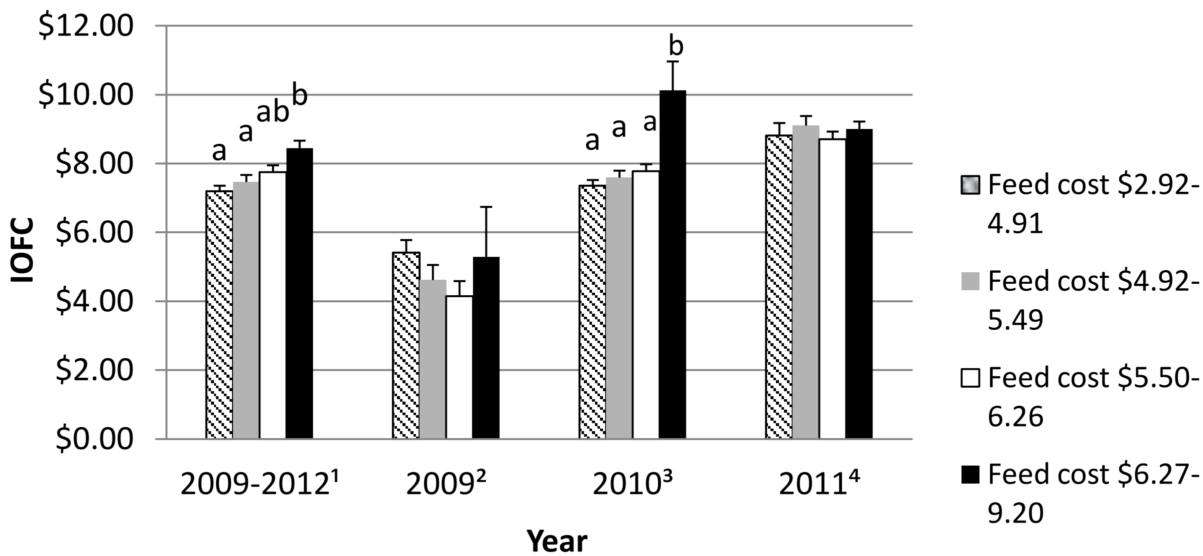
[1]For 2009- 2012 n values in order of increasing quartile ranges were 127, 124,124, and 125. Forage cost Forage costs of $0.78-1.44 have significantly lower milk yield.

[2]In 2009 the n values in order of increasing quartile ranges were 6, 11, 25 and 28. Forage costs between $1.45-1.96 resulted in significantly higher mean milk yield.

[3]In 2010 the n values in order of increasing quartile ranges were 62, 62, 41, and 38. This year resulted in no difference in milk yield with change in forage cost.

[4]In 2011 the n values in order of increasing quartile ranges were 55, 47, 51, and 45. The forage cost between $1.97-3.82 resulted in significantly lower milk yield.

Figure 2. 3. The total feed cost per cow per day in a ration and the income over feed cost (IOFC) using cost quartiles and an ANOVA for the combined years of 2009-2012 and the individual years of 2009, 2010, and 2011.



[ab] Means with different superscripts differ by $P<.05$.

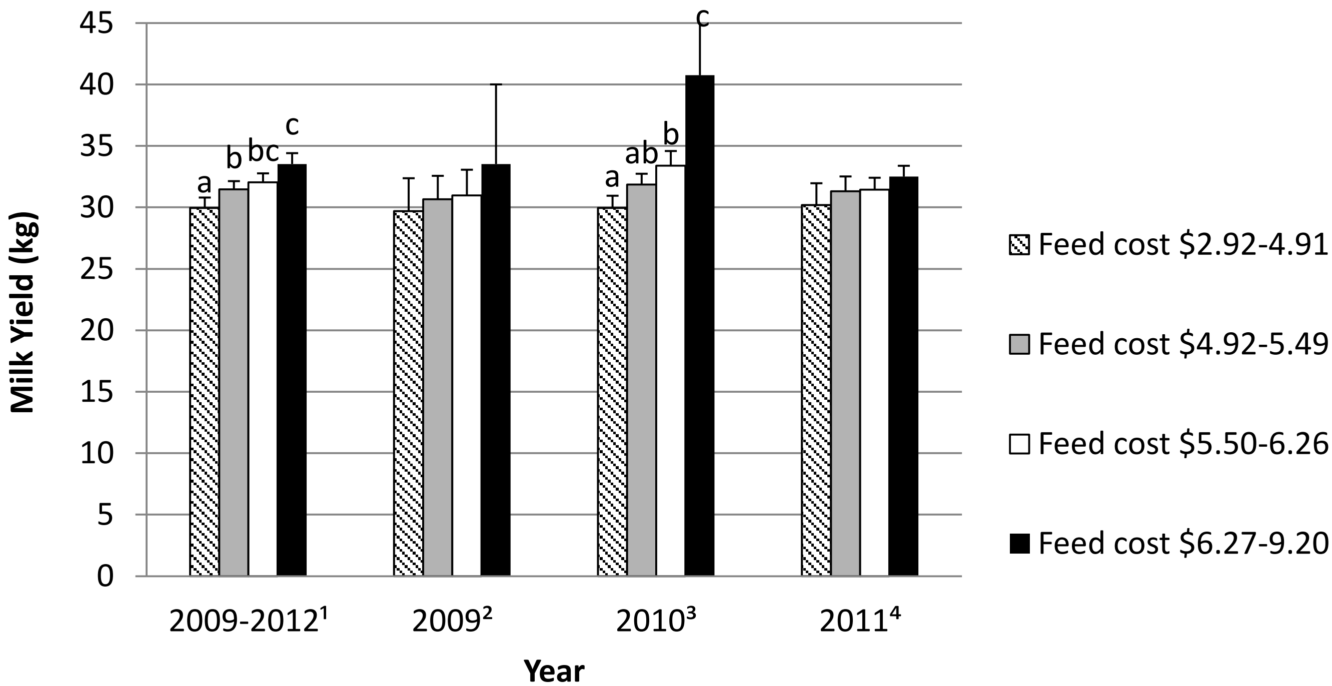
[1]For 2009- 2012 n values in order of increasing quartile ranges were 127, 124,124, and 125. The feed cost between $6.27-9.20 resulted in higher IOFC when compared to total feed costs of $2.92-5.49.

[2]In 2009 the n values in order of increasing quartile ranges were 21, 23, 18 and 8. In 2009, there was no effect on IOFC related to total feed cost.

[3]In 2010 the n values in order of increasing quartile ranges were 92, 65, 40 and 6. The total feed cost quartile of $6.27-9.20 was significantly higher IOFC when compared the other ranges.

[4]In 2011 the n values in order of increasing quartile ranges were 14, 35, 63 and 86. In 2010 there was no effect on IOFC in relation to total feed cost.

Figure 2. 4. The total feed cost per cow per day in a ration and the impact milk yield using cost quartiles and an ANOVA for the combined years of 2009-2012 and the individual years of 2009, 2010, and 2011.



[abc] Means with different superscripts differ by P<.05.
[1]For 2009- 2012 n values in order of increasing quartile ranges were 127, 124,124, and 125. The data is non-normal at the 0.03 level. The total feed cost of $6.27-9.20 resulted in higher milk yield when compared to total feed costs between $2.92-5.49.
[2]In 2009 the n values in order of increasing quartile ranges were 21, 23, 18 and 8. In 2009, there was no effect on milk yield related to total feed cost.
[3]In 2010 the n values in order of increasing quartile ranges were 92, 65, 40 and 6. In 2010, total feed cost of $6.27 and higher milk yield.
[4]In 2011 the n values in order of increasing quartile ranges were 14, 35, 63 and 86. P = 0.058, and trending toward having the total feed cost of $6.27-9.20 resulted in the highest milk yield.

Chapter 3

A Survey of Feeding Management Practices and By-product Feeds Usage on Pennsylvania Dairy Farms

ABSTRACT

Feed management is an important daily activity on dairy farms. Due to tight profit margins and higher feed costs, many producers incorporate by-product feeds into their rations. Dairy industry experts offer many suggestions about ration formulation and feeding management; however, it is unclear what practices are being followed with regard to either ration formulation or the use of by-product feeds. This study used an electronic survey to gather information about feeding management and the use of by-product feeds in rations for a subset of Pennsylvania dairy farms in 2013. The survey was sent to 200 dairy farms via email, and 41 surveys were completed. The survey was first sent out in November 2013, and the last response was received in April 2014. All survey responses were based on the month of September, 2013. This was not a random sampling. These herds were selected from the Penn State Extension database and those from the database willing to take surveys. Most (97.6%) survey respondents fed a total mixed ration (TMR). About half (48.8%) fed one TMR to all their lactating cows, and about half (48.8%) fed more than one TMR to all their lactating cows. Over half (58.5%) of the respondents fed a 60:40 forage to concentrate ratio for the ration. Distillers grains and brewer's grains and yeasts were the most commonly used by-product feeds. Responding producers analyzed dry matter most frequently biweekly (34.1 %) or when switching feeds (34.1 %) and at least once a week (26.8%). However, 60.9% of respondents dry matter tested the recommended interval of biweekly or once a week. Most TMR and forage nutrient testing was done when switching feeds, except for by-product commodity feeds, which most producers never nutrient tested. Most dairy producers used PC Dart as a management tool. This study summarizes feeding management practices used by responding Pennsylvania dairy farms with regard to nutrient content testing. Dairy producers that responded to the survey were successful at feed management, but increasing the amount of nutrient testing on by-product feeds and the use of dairy data analysis tools could improve their success.

INTRODUCTION

In the dairy industry today, feed and milk prices change continuously. This creates a volatile market for dairy farms and challenges for profitability (CME Group Inc, 2013). Since feed costs typically are about 50% of the total cost to produce milk, farms are seeking ways to decrease feed expenses. Many farms are increasing the use of less expensive by-product feeds as an alternative to more traditional feeds in their rations. The use of by-product feeds can also help reduce the dairy industry's dependency on grains, such as corn, that can be expensive (Grasser et al., 1995). By-product feeds are often used in pre-mixed feeds from feed companies. They can also be purchased on a commodity basis, in bulk delivered directly to the dairy. When used on a commodity basis, by-product feeds have been shown to be quite variable in nutrient content (Kertz, 1998, Belyea et al., 1989, DePeters et al., 2000). Variability in feedstuffs has been problematic for dairy farms for many years. This variability has many causes, such as different processors, sources, soil differences, storage, and on farm ration mixing (Kertz, 1998). Lowering the variability in a feed source in a ration can lead to increased milk and decreased feed shrink (Weiss and St-Pierre, 2009). One management tool to decrease feed variability is for farms to send feed samples to a laboratory to analyze the nutritional content of the feeds for their rations. This analysis information is then used to balance the rations for that dairy farm. However, how often and which feeds are sent for testing varies by farm. A nutritionist can use book values that estimate the nutritional content of a feed in order to balance a ration. By-product feeds' nutrient content varies, but book values for these feeds are often used in rations (DePeters et al., 2000). Using book values for feeds has been shown to be less accurate than using actual nutrient analysis, resulting in rations with either excesses or deficiencies in specific nutrients (Arosemena et al., 1995). In contrast, Weiss et al. (2013) found that variation in long chain fatty acids reduced intake and milk yield, but variation of silage dry matter and forage quality had no impact on intake or milk yield. Further research suggested that dairy cattle can adapt to variation in the diet if that variation occurs over a few days (Yoder et al., 2012).

A by-product feed is any product that resulted from the processing or harvest of another commodity that has value as feedstuffs for animals, but not for human consumption (Grasser et.al., 1995). Some examples of by-product feeds are the citrus pulp left after juicing, and cotton seeds left from the extraction of the cotton fibers. The available by-product feeds are often related to the availability in a certain geographical area of the United States and the season. Different by-product feeds can be used to increase the amount of a certain nutrient in the diet. For example, canola meal is high in protein and can be used instead of soybeans, when soybeans are more expensive. In the same fashion, bakery waste was a good source of sugar and soy hulls made a good forage substitute (Hall and Chase, 2014). These waste products would otherwise end up in a land-fill or other waste storage site, so feeding them to livestock has environmental benefits. Also, since the waste products sold, the processers brought in extra income in addition to saving on waste disposal (Grasser et al., 1995, DeGroot et al., 2007). On the other side, the farmer can substitute a less expensive feed in order to lower feed costs. The objective of this study was to summarize feeding management practices used by Pennsylvania dairy farms, with special emphasis on the use of by-product feeds.

MATERIALS AND METHODS

A survey was constructed to examine both feeding management practices as well as the use of by-product feeds on Pennsylvania dairy farms. The survey contained 17 total questions and took about seven minutes to complete. The longest completion time was one hour 26 minutes and the shortest completion time was 3 minutes. The first two questions inquired about herd size and milk yield for the month of September 2013. The remaining questions were focused on feeding management and by-product feed use including: use of total mixed rations (TMR), frequency of nutrient testing on different feeds, frequency of dry matter testing, the forage to concentrate ratio of the diet, use of by-product feeds in rations and the use of dairy data analysis tools. The last few questions were designed to find the opinion of the survey participants about the difficulties of feeding management and use of by-products as a commodity feed.

This survey was e-mailed to about 200 Pennsylvania dairy farms in the Pennsylvania State Extension Dairy Team farm database that were willing to take surveys with a link to a survey.   This was not a random sample. Farms in the database who were not willing to take surveys in the past or without a current email were excluded from the survey. These 200 farms were chosen from a grouping of herds that participated in previous feeding management projects and represented about 3% of the total number of farms in Pennsylvania. This survey had 41 producers respond. Survey Monkey was the program used to collect responses (Survey Monkey Inc.). The survey was sent out on three separate occasions as reminder to those who had not yet responded using Survey Monkey. The first reminder was sent out two weeks after the initial survey was sent out, and the second reminder was sent out five weeks after initial survey was sent. A third and final reminder was sent out in early March to farms had still not taken the survey.

RESULTS AND DISCUSSION

From November 2013 to April 2014, 41 responses were received out of the 200 survey links that were sent for a response rate of 20.5%. This response rate was similar to other agricultural surveys, which have had about a 20% response rate (Weber and Clay, 2013). For the 41 Pennsylvania dairy farms that responded to this survey, the average herd size was 288 ± 314.7

and the average milk yield was 33.1 ± 4.61 kg. The respondents in this dataset had a higher average herd size than the average Pennsylvania herd size of 90.8 ± 123.4 and a slightly higher milk yield compared to the average for Pennsylvania dairies of 31.9 ± 5.1 kg in the same timeframe (Dairy Records Management Systems). The dairy farms in this study used mostly TMRs for most groups of cows (Table 3.1) with 97.6% using TMRs for lactating cows and 75.6% using TMRs for dry cows. Producers responded that 48.8% fed more than one TMR to the lactating cow groups, and 48.8% fed only one TMR to all the lactating cows. No TMR was fed by 4.9% of the respondents. One reason for feeding a TMR was to reduce the variability of the ration that was fed to the cow (Leahy 2013). In a study by Bolton, 2010, many farms chose only to feed one ration to all the lactating dairy cows in order to save on labor and equipment, and to make sure all the cows received enough feed for maximum milk production. In the current study, a majority (58.5%) of producers estimated that their forage to concentrate ratio was 60% forage to 40% concentrate (Table 3.2). Other research showed that increasing the concentrate in a diet to 55%, had no negative impacts on a dairy cow's body weights, body score, but it did increase milk yield (Machado et al., 2014). Yang et al. (2001) found that low forage to concentrate ratio of 35:60, had no impact on rumen pH, increased milk yield and milk protein, but decreased milk fat. In the current study only 14.6% of producers reported having less than 50% forage in the diet, but 12.2% were not sure or selected other. It was reported by Halmemies-Beauchet-Filleau et al. (2014) the use of red clover silages and grass silages in a 60:40 forage to concentrate ratio yielded between 27.2-28.7 kg, somewhat lower milk yield than the current study. However concentrates are more expensive and will increase feed costs. It is not surprising that a majority of the producers in the current study used a ration that was at least 60% forage.

In this study, the three most used by-product feeds were distillers grains (17 rations), brewer's grains and yeasts (14 rations) and animal protein (feather, blood and fish meal) (12 rations) (Table 3.3). These may be the most frequently fed by-product feeds because they are readily available in Pennsylvania. Also, distillers grains and animal protein are high in protein, showing that dairy producers may have been looking for alternative feed sources to higher priced soybeans. Producers analyzed dry matter most frequently biweekly (34.1 %) or when switching feeds (34.1 %) (Table 3.4). However, 60.9% of producers dry matter test in the recommended interval of weekly or biweekly. McBeth et al., (2012) found dry matter fluctuation in silage decrease dry matter intake with increased moisture, but had only a small impact on milk yield. In the current study, dairy farmers most often nutrient tested the TMR (31.7%), corn silage (48.8%), haylage (56.1%), and other forages (60.0%) at a feed change, like switching to a new silo. However, 35.0% dairy farmers did not nutrient test their commodity by product feeds at all (Table 3.5). Given the high degree of variability in by-product feeds (DePeters et al., 2000), this high percentage of farms not testing were at risk for over or underfeeding nutrients in the ration leading to a lower income over feed cost, especially if milk production is impacted (Buza et al., 2014). Kertz (1998) reported that variability in a TMR can come from mixing, weighing, handling, storage, and variability within a feed, and the study suggested that TMR be monitored for variability with nutrient testing (Kertz, 1998). Leahy, (2013) suggested that variation in a TMR can come from the mixer wagon, too short of a mixing time, and incorrect adding of liquids. Leahy also suggested nutrient testing of the TMR (Leahy, 2013). Sova et al., (2014) reported that the greatest variability in a TMR was between the formulated ration and the ration being fed. Less day to day variation in the energy level of the TMR led to greater dry matter intake and milk yield (Sova et al., 2014). In contrast, Weiss et al., (2013) showed that dairy cattle can adapt to daily variation in the diet without a corresponding drop in milk yield. Also Yoder et al. (2012) reported variably in forage to concentrate ratio and forage quality had no impact on milk yield. Use of income over feed cost as a management tool can be beneficial for dairy producers, especially when utilizing more variable by-product feeds; however, only 34.1% of the survey respondents indicated that they used IOFC. Most of the producers (75.6%) use PC Dart as a dairy data analysis tool.

CONCLUSION

This study summarized feeding management practices on Pennsylvania dairy farms. Most farms were feeding TMRs, but only about half were feeding multiple lactating group TMRs and about half were feeding one TMR to all lactating animals. Over half of dairy farms had a 60:40 forage to concentrate ratio in the ration. Distillers grains, brewer’s grains and yeast and animal protein were the most commonly fed by-product feeds. Responding producers were dry matter and nutrient testing of forages within industry recommendations. However, nutrient testing of by-product feeds should be increased in dairy producers feeding management, because of the variability of these feeds. Overall, many dairy producers reported following the recommendations in feeding management made by many industry experts.

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Table 3.1 Description of total mixed ration (TMR) types fed in the last year on Pennsylvania dairy farms

Answer Options	Response, %
One TMR	
Lactating cows	48.8
Dry cows	61.0
Heifers	41.5
More than one TMR	
Lactating cows	48.8
Dry cows	14.6
Heifers	34.1
TMR is not fed	4.9
Other*	12.2

n=41
Multiple answers for each responder
*Other responses included an addition of free choice dry hay, and only partial TMR being fed.

Table 3.2 Estimation of forage to concentrate rations in lactating cow rations for September 2013 on Pennsylvania dairy farms

Answer Options	Response, %
40% forage 60% concentrate	7.3
50% forage 50% concentrate	7.3
60% forage 40% concentrate	58.5
70% forage 30% concentrate	17.1
Not sure	9.8
Other	2.4

n=41

Multiple answers for some responders

Table 3.3 A list of all the commodity by-products used in the rations of Pennsylvania dairy farms

Answer Options	Lactating ration	Dry cow ration	Heifer ration
No by-product used	4	7	8
Bakery product	10	0	0
Beet pulp	2	0	1
Brewer's grain and yeast	13	3	5
Citrus pulp	4	1	1
Distiller's grain	16	5	5
Corn gluten feed	7	1	1
Cotton seed	11	2	1
Cotton seed hulls	1	0	0
Hominy	1	0	0
Tallow	1	0	0
Soy hulls	9	4	2
Wheat mids	4	1	2
Whey	3	1	1
Animal protein*	11	6	1
Not sure	2	3	2

*Animal protein includes feather, blood or fish meal
n=40
Multiple answers for each responder

Table 3.4 Description of how often frequently Pennsylvania dairy farms test the dry matter of the feeds in the ration

Answer Options	Response, %
At least once a week	26.8
Biweekly	34.1
Monthly	19.5
Bimonthly	2.4
At feed change	34.1
Not at all	2.4
Other*	7.3

n=41
Multiple answers for each responder
*Other responses included when intake changes.

Table 3.5 Description of how frequently dairy farms nutrient tested different feed types and rations in the past year

	TMR*	Corn silage*	Haylage*	Other forages**	Commodity by-product feed**
Answer Options	Response, %	Response, %	Response, %	Response, %	Response, %
Monthly	26.8	34.1	39	15	2.5
Bimonthly	2.4	24.4	12.2	12.5	2.5
Quarterly	24.4	12.2	7.3	12.5	15.0
At feed change	31.7	48.8	56.1	60.0	12.5
Do not use	0	0	2.4	2.5	7.5
Not sure	4.9	0	0	0	22.5
Not at all	14.6	0	2.4	5.0	35.0
Other	12.2‡	12.2†	4.9ɫ	10.0†	10.0‡‡

*n=41
**n=40
Multiple answers for each responder
‡Other responses included 1-3 times annually, or during poor performance
† Other response included randomly as feeding out a bunker, after it as fermented for a month, and biweekly
ɫ Other response included randomly as feeding out a bunker
‡‡ Other responses include when intakes change or if dry matter seems to change due to variety change

Table 3.6 Description of use of dairy data analysis tools for Pennsylvania dairy farms.

Answer Options	Response, %
Penn State Income Over Feed Cost Tool*	19.5
Other income over feed cost calculation	14.6
Penn State Profitability Assessment Dairy Tool**	4.9
DairyComp 305†	7.3
PCDart‡	75.6
None	2.4
Other	9.8

n=41
Multiple answers for each responder
*Ishler, V., T. Beck, K. Bailey, E. Cowan, and K. Dickson. 2013. Penn State income over feed cost tool. Accessed Feb. 20, 2014. http:// extension.psu.edu/animals/dairy/business-management/financialtools/ income-over-feed-cost/penn-state-income-over-feed-costtool/ view.
** Beck, Tim et al., 2006. Penn State Profitability Assessment Dairy Tool. Penn State Dairy Extension Team.
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† Dairy Comp 305 Valley Agricultural Software, Tulare, CA

‡ PC DART Dairy Records Management Systems, Raleigh, NC,

Chapter 4

Impact of Dairy Advisory Teams on Farm Improvement in Pennsylvania Dairies

ABSTRACT

Dairy producers continuously seek ways to improve their farm, and many choose to form a dairy advisory team (DAT) to improve management. The objectives were: (1) to compare key measures before and after the team in order to determine if the use of a DAT was effective and (2) to compare a group of 24 herds with a DAT to Pennsylvania (PA) averages for key measures. Teams were formed between May 2008 and January 2013. The range in herd size was 32-608±13.96 cows. Herd size, milk yield, somatic cell score (SCS), peak milk yield, age at first calving (AFC), days in milk (DIM), pregnancy rate and cull and mortality rates were key measures analyzed. The changes in key measures, after using DAT for at least one year, were analyzed using a general liner models and contrasts. After DAT use for one year, herds had significantly (P<0.05) higher percent of herd with SCS 1-3 of 76.92 vs 73.79 % and higher peak milk in the third plus lactation with 45.60 vs. 43.30 kg. After DAT use for more than one year, herds had significantly (P<0.05) higher milk yields of 33.56 vs. 31.13 kg. As well as lower AFC of 25.50 vs. 24.45 months and higher percent of herd with SCS 1-3 of 79.85 vs. 73.4 %. After use of DAT for more than one year, herds had lower days in milk (DIM) of 173 vs. 187 and higher peak milk in the third plus lactation of 47.4 vs. 43.3 kg. The DAT herds' January Dairy Herd Improvement Association (DHIA) test data were compared to Dairy Metric's PA average for January 2014 using a one-sample t-test. Farms with DAT had significantly (P<0.05) higher

milk yield of 33.9 vs. 31.9 kg and peak milk yield for first lactation with 36.1 vs. 33.9 kg. There was no significant difference between the averages for DAT herds and PA herds for peak milk yield in older cows, but DAT herds had numerically higher peaks (44.3 vs. 42.7 kg and 47.4 vs. 45.9 kg for 2nd and 3rd lactation, respectively) in older cows. Herds with DAT had significantly ($P<0.001$) lower AFC of 24.4 vs. 25.6 months and higher percentage of herd with SCS 1-3 79.85 vs 73.4%. There were no differences for pregnancy rate, DIM, cull or mortality rates. Use of DAT led to greater milk yield, lower AFC and better SCS. Herds with DAT had higher milk yield, lower AFC and better SCS compared to PA averages. Use of a DAT was beneficial to dairy farms.

INTRODUCTION

In past years the dairy industry has found itself in turbulent economic times with the volatility of both milk and feed prices. With tighter profit margins, many dairy producers sought ways to improve decision making in order to be more profitable. Some farms chose to form a dairy advisory team (DAT). The use of a DAT or modification of a DAT has become more common with many dairies across the United States (DAIReXNET, 2012). These teams are designed to help farms who are in need of assistance in a focused area or are looking for other ways to improve. A DAT is a regular assembling of a dairy farm's advisors. This included veterinarians, nutritionist, bank lenders, crop experts, reproduction specialists, extension educators, herd mangers and family members (Holden & White, 2013). Some teams had a non-farm member who served as the coordinator or facilitator for the meetings of the DAT (Heald et al., 2002). Dairy advisory teams met regularly, but the time between meetings depended on the team and the farm's needs (Heald et al., 2002). Implementing a DAT is one way to target bottlenecks and find solutions to problems. These teams may try to meet a dairy farm's set goals, for example, lowering somatic cell counts (SCC) or increasing milk yield (MY). Other goals of the team were to improve dairy farm life and farm profitability (Weinand and Conlin, 2003). In an earlier study, Heald et al showed that DAT with long term goals rather than only short term goals had better success in improving management. Also, smaller herds showed more immediate progress after having a DAT (Heald et al., 2002).

Although some research has shown that teams can be successful, there is limited data about the overall impact of teams on productivity and profitability. To determine the success of the DATs, actual farm information is needed to determine which areas the DATs are improving and how long it takes to improve these areas. The objectives of this study were: (1) to compare key measures before and after the team formation in order to determine if the use of a DAT was effective and (2) to compare a group of 24 herds with a DAT to Pennsylvania (PA) averages for key measures.

MATERIALS AND METHODS

This study collected a list of PA dairy herds that had registered the use of DAT with the Center for Dairy Excellence (CDE) (http://centerfordairyexcellence.org/). Herds were sorted according to data availability, and any herds not having DHIA data available electronically six months prior to the start of the DAT through 18 months post DAT start were eliminated. Of all the herds registered with CDE, only 24 had data available electronically for this entire timeframe. The key measures for this study were herd size, milk yield (MY), peak milk by lactation, fat and protein percent, somatic cell count (SCC) and somatic cell score (SCS), age at first calving (AFC), cull and mortality rate, pregnancy rate (PR), and days in milk (DIM). Key measures were recorded from six months before the start of the DATs (BEF) until one year after the activation of the DATs (AFT). Data for the six months before the DATs were averaged and compared to the average of one year after the start of the DATs. In order to compare the farms with a DAT at a current point of time with other farms, January 2014 (CUR) key measures were recorded. This data was analyzed against Dairy Metric data for the state of Pennsylvania for the same month using a t-test in Minitab (Minitab® Statistical Software, 2010). The key measures for six months before the DAT, one year after the DAT, and current January 2014 data were contrasted in a PROC GLM in SAS software 9.3 (SAS Institute Inc, 2011) with a least squares means analysis. The contrasts for this analysis were BEF vs. AFT and BEF vs. CUR..

RESULTS AND DISCUTION

Results for the 24 DAT herds analyzed before DAT use had a mean lactating herd size of 137 ±9.2cows and a milk yield of 31.2 ± 0.34 kg. (Table 4.1) The mean fat percent was 3.8 ±0.11% and the mean herd SCS 1-3 was 73.6 ±1.89%. The mean AFC was 25.3 ± 0.12 months and the mean DIM was 187 ±1.72 (Table 4.1).

In the contrast least square means analysis of the key measures of six months before the DATs (BEF) to one year after the DATs (AFT) the percent of the herd with a SCS less than 3 was significantly ($P < 0.05$) lower from 73.79% to 76.92% (Table 4.2). The peak milk from the 3+lactations increased ($P<0.01$) from 43.3 to 45.6 from BEF to AFT. With an n value of 15, mean pregnancy rate increased ($P<0.05$) from 13.43% to 16.61% from BEF to AFT. Comparison of key measures from before the DAT (BEF) to current (as of January, 2014) (CUR) are presented in Table 4.2. Comparing herds BEF to CUR resulted in an increased ($P<0.001$) MY of 31.72 kg compared to 33.56 kg (Table 4.2). The mean percent of the herd with a SCS of 1-3 increased ($P<0.001$) from 73.79% to 79.85% from BEF to CUR (Table 4.2). The mean AFC decreased ($P<0.01$) from 25.5 to 24.45 month from BEF to CUR. The mean peak milk in 3+ lactation increased ($P<0.001$) from 43.3 to 47.4 kg from BEF to CUR. The mean DIM decreased ($P<0.001$) from 187 to 173 days from BEF to CUR. With a n value of 15, mean pregnancy rate increased ($P<0.05$) from 13.43% to 17.2% from BEF to CUR. However, all dairy herds, with or without a DAT, would be expected to improve in milk yield and other key measures because of an improvement in herd genetics that takes place over time with the incorporation of replacement animals into the herd (Weigel, 2010). It should be noted that because teams started throughout the year, some herds may have BEF data that are reflective of different seasons compared to AFT. No analysis of season was included in these data and . Since the start dates varied by month, differences do to seasonality should be minimal.

A t-test analysis was used to compare the 24 DAT herds in January 2014 to PA averages from Dairy Metrics. This was a comparison of a single point in time between the DAT herds and PA herds, and it was unknown whether or not the PA averages were from herds with or without teams. The mean MY was higher ($P<0.05$) for DAT herds at 33.98 kg than average PA herds at 31.93kg (Table 4.3). The mean percentage of the herd with a SCS of 1-3 was higher ($P<0.001$) at 79.85% for DAT herds than average PA herds at 73.4%. The mean AFC was lower ($P<0.001$) at 24.45 months for DAT herds than average PA herds at 25.6 months. The mean peak milk in first lactation was higher ($P<0.05$) at 36.1 kg for DAT herds than average PA herds at 33.9 kg.

When looking at the significant difference in milk yield for DAT compared to average PA herds of 33.98 kg (73.9 lbs) to 31.93 kg (70.4 lbs) and assuming a $20.00/cwt milk price and a 100 cow herd, this yield difference due to having a DAT would result in an extra $14,600 annually (milk income minus 50% for feed cost) in income.

When comparing data before and after use of a DAT, the DAT herds in this study showed improvements in MY, SCS, AFC, peak milk in 3+ lactation, DIM and PR. Some of the farm improvements happened within the first year of having a DAT. However, the DAT continued to generate improvement beyond the initial year of operation. Looking at the DAT herds at a current time point showed that many herds needed more than one year to make significant improvements in a number of key measures. Heald et al. (2002) showed that smaller herds (less than 200 cows) show improvements faster than larger herds . With the herd range being 32 to 608 cows this could have had some impact on how quickly the DAT herds showed improvements. Differences by herd size were not analyzed in the current study due to small numbers of herds overall. These herds with DATs were significantly better in MY, herd SCS, AFC, and peak milk 1st lactation, but significantly lower in fat percentage compared to PA averages. The PA average herds may have included some herds that had DATs not registered with the Center for Dairy Excellence. With this analysis there was no way to determine or exclude those herds.

The improvements made by DATs on these dairy farms had many advantages. With the reduction of SCS, these herds would produce more milk, receive more quality bonuses, have less waste milk and save on the cost of sub-clinical and clinical mastitis. Geary et. al. (2012), used a model including milk losses, culling, testing, treatment, veterinary attention, waste milk and penalties to find that an increase of bulk milk somatic cell count (BMSCC) from less than

100,000 cells/ml to more than 400,000 cells/ml, milk income reduced income from €148,843 to €138,573. Bar et al. (2008) found that clinical mastitis cost $179.00 per case per cow a year. Ruegg (2000) collected information from 54 herds and reported the range of milk quality premiums per month was from $6.70 to $15.02. Using a milk price of $0.20 per pound, having a SCS higher than three cost a producer $40 per cow per lactation in production losses for first lactation animals, and $80/cow/lactation in second plus lactation animals (Ruegg, 2005). With the difference of the percent of the herd with a SCS of 1-3, of 79.3% for DAT herds and 73.4% for average PA herds, and assuming a 100 cow herd and a milk price of $20.00/cwt, DAT herds would have an extra $4,200 a year from reduced mastitis costs and improved milk yield. Additionally, the reduction of SCS in DAT herds could earn farms more profits in premiums and save money on the reduced cost of mastitis.

Reproductive management was also an area where the DAT herds improved. However, it was the least reported variable by all of the farms. Using a bioeconomic model, De Vries (2006), found that the average value of a new pregnancy is $278. This number is increased when pregnancy was achieved earlier in lactation and decreased if achieved later in lactation. The average cost of pregnancy loss was $555. The increase of pregnancy rate from 13.43% from 6 months before the DAT to 17.2% with having a DAT currently gained the farm about $94.25/cow/year (De Vries, 2007). Improving pregnancy rate, and reducing the number of services would save money on many farms.

Dairy Advisory Team herds improved AFC after having a team for longer than one year. These herds were also higher than the PA average herds for AFC. The AFC was another key measure that had economical implications. Tozer and Heinrichs (2001) found using a model, that the reduction in AFC by one month would reduce the cost of a replacement program of a

100 cow herd by $1,400.00 or 4.3%. A cost analysis spreadsheet was created by Gabler et al. (2000) to find the cost of raising replacement heifers. The average was found to be $1124.06 for milking operations and $1019.20 for custom operations to raise a heifer. The use of DAT in January 2014 compared to PA averages, with the of 24.7 to 25.6 months for DAT herd and PA herds (table 4.3) would save $1400.00 annually for a 100 cow herd (Tozer and Heinrichs, 2001). This again showed that by lowering the AFC dairy producers can save money.

CONCLUSION

Dairy advisory teams improved herd SCS, peak milk for 3+ lactation and pregnancy rate within the first year of having a DAT. After having the DAT for longer than one year, these herds showed improvements in milk yield, age at first calving, and days in milk, as well as a continuation of improvements in herd SCS, peak milk for 3+ lactation and pregnancy rate. When comparing DAT herds to PA average herd for January 2014, DAT herds were higher in milk yield and peak milk for 1st lactation, as well as, lower in herd SCS and age at first calving. This study showed that DATs were successful on farms in Pennsylvania, and DATs can be used as an important management tool for many farms to improve both productivity and profitability.

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Table 4.1 Descriptive statistics of the 24 farms before the use of a team and key measures used in this study

Item	Mean	SEM	Range
Number of lactating cows	137	9.2	29-615
Milk yield/lactating cow/day, kg	31.2	0.34	21.7-43.72
Fat, %	3.8	0.11	2.9-4.3
Protein, %	3.1	0.09	2.80-3.5
Weighted average SCC	253	9.54	40-614
Herd SCS 1-3, %	73.6	1.89	51-94.0
Average age at first calving (AFC)	25.3	0.12	22.0-33.0
Cull rate, %	31.1	2.0	2.4-40.78
Mortality rate,%	5.1	0.91	0-15.3
Peak milk 1st lactation, kg	35.2	0.39	21.8-41.7
Peak milk 2nd lactation, kg	43.3	0.39	28.8-54.8
Peak milk 3rd+ lactation, kg	43.3	0.80	24.9-55.3
Days in milk (DIM)	187	1.72	147-268
Pregnancy rate*, %	13.4	0.46	5.0-24.0

* Pregnancy rate n=15. This was the least recorded of all the key measures.

Table 4.2 Dairy advisory team (DAT) contrast least square means analysis of management key measures before the DAT (BEF), after the DAT (AFT) and current averages (January 2014) (CUR) of the herds with DATs

Item	BEF mean†	AFT mean‡	CUR mean ƚ ƚ	Standard error	BEF vs. AFT	BEF vs. CUR
Milk yield/lactating cow/day, kg	31.13	31.72	33.98	1.733	0.2457	<0.0001
Fat, %	3.72	3.73	3.76	0.1761	0.7968	0.2057
Protein, %	3.09	3.10	3.13	0.0009	0.7250	0.0639
Weighted average SCC	253.39	220.47	197.80	69.033	0.1053	0.0076
Herd SCS 1-3, %	73.79	76.92	79.85	5.143	0.0406	0.0005
Average age at first calving (AFC)	25.5	25.02	24.45	1.010	0.1025	0.0062
Cull rate, %	31.08	33.37	36.34	13.359	0.5545	0.1994
Mortality rate,%	5.12	5.37	5.62	2.728	0.7519	0.4294
Peak milk 1st lactation, kg	35.01	34.11	36.10	2.225	0.1675	0.2735
Peak milk 2nd lactation, kg	43.30	43.62	44.30	2.919	0.7111	0.2169
Peak milk 3rd+ lactation, kg	43.30	45.60	47.40	2.383	0.0017	<0.0001
Days in milk (DIM)	187.04	185.89	173.0	12.437	0.7496	0.0009
Pregnancy rate*, %	13.43	16.61	17.2	3.06	0.0107	0.0142

†This is the mean of the key measures of the farms 6 months before the creation of the dairy advisory team

‡This is the mean of the key measures of the farms 1 year after the creation of the dairy advisory team

ƚ ƚ This is the mean of the key measures of the farms from the month of January 2014 or at the current time

* The n for pregnancy rate was 15. For all other key variables the n was 24.

Table 4.3 Mean comparison of the 24 dairy farms using dairy advisory teams (DAT) management key measurements against Dairy Metrics† data for the month of January 2014 with the use of a t-test analysis.

Item	DAT (1/2014)	Dairy Metrics (1/2014)
Milk Yield/lactating cow/day, kg *	33.98	31.93
Fat, % **	3.76	3.9
Protein, %	3.13	3.1
Herd SCS 1-3,% ***	79.85	73.4
Weighted SCC	197.8	215.2
Average age at 1st calving (AFC) ***	24.45	25.6
Cull rate, %	36.34	36.4
Mortality rate,%	5.624	4.4
Peak milk 1st lactation, kg *	36.1	33.9
Peak milk 2nd lactation, kg	44.3	42.7
Peak milk 3rd+ lactation, kg	47.4	45.9
Days in milk (DIM)	173	175.3
Pregnancy rate,%‡	17.2	17.9

†The filter on Dairy Metrics was for Pennsylvania herds only and all Holstein herds only, to match the demographic of the teams in this study

*P<0.05

**P<0.01

**P<0.001

‡The n for pregnancy rate for the DAT herds was 15.

Chapter 5

Recommendations

The research presented in this thesis has shown the benefits of the use of the IOFC calculation and the use of DAT. This research also summarized current feed management practices on the responding farms form the survey. This research has many practical on farm applications.

The use of IOFC calculations on a monthly basis allows farms to monitor profit margins and track how ration changes are impacting net income. In different feed and milk markets some rations are better than others. Calculating IOFC on a monthly basis will allow a producer to make best management decisions regarding the ration ingredients and the ability of the feeding program to yield both milk yield and profit. Use of IOFC especially during times of low milk prices, allows producers to make more profitable feeding changes. Without IOFC calculations, lack of profitable response in milk yield to feed changes may go undetected. Using the IOFC calculation this research showed that the higher feed cost resulted in both higher IOFC as well as milk yield. The use of a least cost ration is not always the best option. Since lower cost rations had lower IOFCs, saving money by purchasing cheaper feed did not result in a good return. The amount of purchased feed in a ration had no impact on either milk yield or IOFC. Farms can achieve high levels of both milk yield and IOFC with a feeding strategy using all or mostly purchased feed. However, the use of a high amount of purchased feed may leave a producer more vulnerable to market changes than a producer who grows their own feeds.

Including by-product feeds in a ration led to some higher milk yields; however, IOFC was only significantly higher in 2010. This suggests that when using by-product feeds, IOFC calculations should be done monthly to determine if the use of the by-product feed is cost effective.

In the survey study, a majority of respondents were dry matter testing at the recommended frequency. Since only a small percentage of the respondents tested by-product feeds, there is a large opportunity for improving feeding management by the nutrient testing of by-product feeds for these respondents. Past studies have shown that by-products are variable in their nutrient content. Variability in feed has been shown to impact milk yield. If these by-products were nutrient tested, the rations would have less variability and be more precise, creating a better overall ration for these producers.

The final study of this thesis showed exactly how influential a DAT can be on a dairy farm. Dairy advisory teams can assist with key management decisions and help brain storm solutions to tough issues. Teams are excellent for uncovering problems farms may not have been aware of. Teams hold members accountable for what they agreed to change or do. Some farms use DAT to improve quality of life and assist in succession planning. After having teams farms improve record keeping and better utilize those records. The use of DAT creates open communication between all industry professionals that impact the farm. The impact of DAT showed in milk yield, SCS, pregnancy rate, days in milk and age at first calving were impacted by the use of a DAT. Many of these key measures have direct economic impacts on a dairy farm either by saving money or by increasing income. This study has shown that DAT use can improve both productivity and profitability of dairy farms. In observation, these DAT herds also had improved record keeping over time. Based on economic estimates in this study, a 100 cow herd using a DAT compared to the average Pennsylvania data for that same 100 cow herd would gain $296 per cow advantage when milk price was $20 per cwt.

Overall, many farms can make changes to improve management. The use of a monthly IOFC calculation and a DAT will help a farm find and correct management issues in the ration or on the farm. Feeding management on many dairies is good, but also has potential for improvements. Nutrient testing of by-product feeds is one key area that can be changed to reduce variation in rations and potentially improve milk yield and IOFC.