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Case Report – Two Nutritional Interventions in Dairy Cattle Herds Helped Improve Productivity and Animal Health while Reducing the Environmental Footprint

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Abstract

The Field Investigation group (FI) at the University of Pennsylvania School of Veterinary Medicine was contacted for consulting services for two farms with economic and nutritional management concerns. Farm A was a 732-cow dairy referred by one of the authors (RDE) for concerns over ration cost and transition cow health. Farm B was a 98-cow dairy that contacted FI because of financial difficulties, specifically the high cost of the diets. In both cases, FI veterinarians evaluated and reformulated diets that resulted in positive economic, production, and environmental consequences. Farm A increased test-day milk, fat, and protein yield by 7.2, 0.03, and 0.07 lb (3.3, 0.014, and 0.032 kg)/cow/day after the diet reformulation. The ration also saved $0.45/cow/day while decreasing nitrogen and phosphorus excretion by 1.44 oz (40.9 g) and 0.11 oz (3.12 g)/cow/day, respectively. Farm B increased test-day milk, fat, and protein yield by 1.2, 0.11, and 0.04 lb (0.54, 0.05, and 0.018 kg)/cow/day after FI intervention. Ration cost was reduced by $1.09/cow/day, nitrogen excretion was reduced by 0.3 oz (8.5 g)/cow/day and phosphorus excretion was not changed.

Key words: bovine, dairy, nutrition, environment, environmental sustainability, veterinary service

Résumé

Le groupe d'enquête sur le terrain de la *University of Pennsylvania School of Veterinary Medicine* a été consulté par deux fermes aux prises avec des problèmes économiques et de gestion de l'alimentation. La ferme A comportait 732 vaches laitières et éprouvaient des difficultés au niveau du coût de la ration et de la santé des vaches en transition. La ferme B comportait 98 vaches laitières et demandait de l'aide au groupe d'enquête concernant des problèmes financiers émanant surtout du prix élevé des aliments. Dans les deux cas, les médecins vétérinaires du groupe ont évalué et reformulé les rations entraînant des retombées positives au niveau de l'économie, de la production et de l'environnement. Après la reformulation de la ration, la production de lait, de gras et de protéines s'est accrue lors du contrôle laitier suivant de 7.2, 0.03, et de 0.07 lb (3.3, 0.01, et 0.03 kg)/vache/jour, respectivement, dans la ferme A. Cette ration a aussi permis de sauver 0.45$/vache/jour tout en diminuant l'excrétion d'azote de 1.44 oz (40.82 g)/vache/jour et de phosphore de 0.11 oz (3.12 g)/vache/jour. Dans la ferme B, la production de lait, de gras et de protéines s'est également accrue de 1.2, 0.11, et 0.04 lb (0.54, 0.05, et 0.02 kg)/vache/jour, respectivement, lors du contrôle laitier suivant l'intervention du groupe d'enquête. Cette ration a aussi permis de sauver 1.09$/vache/jour tout en diminuant l'excrétion d'azote de 1.49 oz (42.24 g)/vache/jour et de phosphore de 0.28 oz (7.94 g)/vache/jour.

Introduction

Dairy cattle nutrition is a complex area of management that spans the domains of agronomy, management, ruminant physiology, and agricultural economics. Nutrition is an area of farm management that has been shown to have significant impacts on milk production, cow health, and farm profitability. More recently, ration formulation has been identified as one way to influence environmental contributions of key nutrients, such as nitrogen and phosphorus.[1,2,12] This case report is an example of nutritional interventions that had positive impacts on milk production, herd health, farm profitability, and nutrient excretion.

History

Two herds were referred to the Field Investigation group (FI) at the University of Pennsylvania School of Veterinary Medicine. Farm A was a 732-cow dairy that was referred by the herd veterinarian for concerns over cash flow in March 2009. The herd veterinarian identified ration cost, increased incidence of left displaced abomasum, and poor transition cow health as areas to be evaluated. Farm B was a 98-cow dairy that contacted the FI because of financial difficulties in June 2009. The primary concern of the farm owner was the high cost of the current ration.

Clinical Findings

Farm A: FI accessed the Dairy Herd Improvement Association (DHIA) records through PCDART[a] to obtain herd production data. On the most recent test date (March 4, 2009), Farm A averaged 71.8 lb (32.6 kg) of test-day milk on 732 cows (lactating and dry). Cows averaged 3.7% fat and 3.1% protein at 185 average days-in-milk. Additional information was made available by the producer on milk shipped per day and through the cooperative on milk urea nitrogen (MUN) levels in the milk for the previous month. Additionally, DC305 records were provided by the herd veterinarian (RDE) to assess postpartum health problems. The primary concern was a 16% annual incidence rate of displaced abomasum.

FI worked with the herd veterinarian to collect all forages and by-product commodities on the farm including corn silage, mixed-grass silage, dry corn gluten feed, and dry corn distillers grains. The samples were submitted to Cumberland Valley Analytical Service[b] for analysis. Forages were submitted for a CPM-Plus analysis which uses wet chemistry to determine the nutrient profile of the sample (Table 1). In addition to a basic nutrient profile, the CPM-Plus analysis offered by CVAS describes the partitioning of protein and carbohydrate fractions. This additional detail enables the software program to more accurately predict the utilization of these nutrients and the resulting milk production and nutrient excretion. A fermentation analysis and 24-hour in-vitro fiber digestibility were also performed on all forages. In combination with the ingredient list (Table 2), results of these analyses were used to describe the lactating ration at time of referral in CPM-Dairy (v3.0.8, www.cpmdairy.com) (Table 3). The primary clinical finding was an imbalance between metabolizable energy (ME) and metabolizable protein (MP). The diet contained enough ME to produce 90.7 lb (41.2 kg) of milk, but only enough MP to support 82.8 lb (37.6 kg) of milk based on a predicted dry matter intake (DMI) of 50 lb (22.7 kg). Further evaluation of the ration description and current feed prices identified an opportunity for significant cost savings. Additionally, supplementation of phosphorus was identified as excessive and the diet formulation resulted in low utilization of nitrogen (N).

Farm B: DHIA records were accessed and downloaded through PCDART. On the most recent test day (June 17, 2009), Farm B had 98 (lactating and dry) cows on test producing 70 lb (31.8 kg) of test-day milk with 3.3% fat and 2.9% protein at 198 days-in-milk.

FI visited the dairy farm to address concerns about high ration cost. At the time of the visit, the cost of the ration was calculated to be $5.92 per cow and $9.76 per cwt (45.45 kg) of milk produced. Two forages, corn silage and triticale haylage, were sampled and submitted to CVAS for CPM-Plus, Fermentation Analysis, and 24-hour in-vitro fiber digestibility as described for Farm A. The ingredients (Table 4) and forage analysis results were entered into CPM-Dairy for evaluation (Table 5). Diet evaluation identified a number of potential problems. Similar to Farm A, the diet at Farm B had an imbalance in ME and MP allowable milk, 77.5 vs 70 lb (35.2 vs 31.8 kg), respectively, at 46.2 lb (21 kg) of DMI. A portion of this imbalance was attributable to a low starch level (18.1%) resulting in inadequate microbial synthesis of MP.

Outcomes

Farm A: A new diet was formulated for 90 lb (40.9 kg) of milk at the same predicted DMI (50 lb or 22.7 kg). The optimizer function of CPM-Dairy was utilized to identify a least-cost ration formulation that met the FI guidelines (Table 2). This ration increased MP from both bacterial synthesis and rumen undegradable fractions to address the imbalance in ME and MP, reducing crude protein (CP) from 17.1% of DM to 16.7% (Table 3). This reduction in CP was accomplished by removing urea, increasing rumen undegradable protein (RUP), and providing adequate substrate for rumen microbial synthesis of MP. The new diet also reduced the inclusion rate of vitamins and minerals to meet National Research Council (NRC) requirements (Table 3). Trace minerals were balanced based on the default values provided by CPM-Dairy for the diet ingredients. In total, the new ration reduced feed cost by $0.45 per lactating cow per day (Table 6). At a profit team meeting, the producer indicated this new ration saved the farm $1,000 every three days or $10,000 per month.

The reformulated lactating ration also had positive environmental impacts. Despite numerous publications observing no difference in milk yield or fertility when phosphorus (P) inclusion exceeds 0.38%, the practice of including excessive P into the diet continues.[2] In this case FI removed inorganic P sources, resulting in a reduction

Table 1. Nutrient analysis of forages from Farm A and Farm B. Items included as part of the CPM-specific analysis are identified with an asterisk.

Forage Analysis					
	Farm A Forages		Farm B Forages		
	Corn silage	Haylage	Corn silage	Triticale	
Moisture, %	66.9	64.1	65.1	72.8	
Dry matter, %	33.1	35.9	34.9	27.2	
Crude protein	7.7	14.7	7.5	16	% DM
ADF protein*	0.6	1	0.7	0.9	% DM
NDF protein*	1.1	2.3	0.8	2.2	% DM
Adjusted protein	7.7	14.7	7.5	16	% DM
Soluble protein	64.8	56.5	64.5	65.7	% CP
Degradable protein	82.4	78.3	82.2	82.9	% CP
Ammonia*	11.8		15.2	21.8	% CP
TDN	71.8	60.2	68.6	59.2	% DM
NEL	0.75	0.62	0.7	0.61	Mcal/lb
NEM	0.77	0.6	0.72	0.58	Mcal/lb
NEG	0.49	0.34	0.45	0.32	Mcal/lb
ADF	24.5	34.6	27.8	38.2	% DM
NDF	45.5	51	42.8	60.1	% DM
Lignin*	2.7	4	2.4	4	% DM
Crude fat*	3.4	3.7	3.1	5.3	% DM
Ash	3.8	12.7	3.2	13.6	% DM
Starch*	28.9	0.7	31.7	0.6	% DM
Sugar*	1.6	5.9	0.9	1.3	% DM
NFC	40.8	20.1	44.2	7.2	% DM
Calcium	0.24	0.69	0.22	0.54	% DM
Phosphorus	0.24	0.33	0.28	0.54	% DM
Magnesium	0.16	0.22	0.12	0.19	% DM
Potassium	0.95	2.68	1.13	4.45	% DM
Sulfur*	0.14	0.23	0.11	0.25	% DM
Sodium	0.009	0.063	0.009	0.061	% DM
Iron	137	1875	102	1060	PPM
Manganese	43	144	21	101	PPM
Zinc	37	36	30	55	PPM
Copper	6	14	5	13	PPM
Chloride*	0.17	0.62	0.32	0.75	% DM

of dietary P. Phosphorus concentrations remained above requirements due to inclusion of by-products (wheat midds and dried distillers grains) high in P content. With this moderate reduction in dietary P, environmental contributions through fecal excretion decreased by 4.5 lb (2.0 kg) per day from the herd. If a similar reduction could be continued for a year, 1,631 fewer pounds (741 kg) of P would be spread as manure fertilizer (Table 6).

Potential environmental loss of N was reduced considerably as reflected by the decrease in MUN. According to data accessed through the cooperative, in the 30 days prior to ration reformulation, the mean MUN was 12.8 mg/dl. The mean MUN dropped to 9.9 over the next 30 days after implementation of the new ration. Using the equation derived by Jonker *et al*,[5] this decrease of MUN equates to a urine-N reduction of 1.44 oz (40.9 g) per cow per day. For a lactating herd of approximately 650 cows, this new ration reduces urine-N excretion by 58.7 lb (26.6 kg) per day and 10.7 tons (9.7 metric tons) per year.

Farm B: FI reformulated the ration to support 80 lb (36.4 kg) of milk with a predicted DMI of 46.2 lb

Table 2. Ingredient list of Farm A ration before and after reformulation.

	Farm A	
	Original	Reformulated
Ingredient profile	lb/cow/day	lb/cow/day
Corn silage (lb DM)	19.800	22.450
Fine ground dry corn	8.800	-
Mixed grass haylage (lb DM)	6.600	4.610
Soybean meal (47.5%)	4.600	5.278
Dry corn gluten feed	4.460	3.838
Corn distillers grains	4.000	3.838
Wheat midds	1.700	1.439
Limestone	0.740	0.576
Straw (lb DM)	0.500	-
DairyPrime74	0.500	-
Animal/vegetable fat blend	0.300	-
Urea	0.200	-
Salt	0.114	0.144
Trace mineral mix	0.110	0.014
Magnesium oxide	0.080	0.058
Vitamin E (20,000 IU/lb)	0.040	-
Vitamin ADE	0.027	0.009
Bicarbonate of sodium susquinate	0.024	0.384
Sodium selenite	0.024	-
Rumensin 80	-	0.004
MetaSmart	-	0.031
Tallow	-	0.115
Blood meal	-	0.835
High moisture corn	-	5.278

Table 3. Farm A nutrient profile before and after reformulation.

Farm A Diet Nutrient Profiles		
Nutrient	Original	Reformulated
CP, %	17.1	16.7
RUP, % of CP	34.2	38.8
NDF, %	33.9	32.7
ForageNDF, % DM	25.4	24.8
Ether extract, %	4.6	4.0
NFC, %	39.5	41.1
Starch, %	25.7	27.2
P, %	0.5	0.4
ME, mCal/d	61.8	61.8
MP, g/d	2,427.0	2,611.0
RUP, g/d	1,092.0	1,238.0
Bacterial, g/d	1,336.0	1,373.0
NEL, mCal/lb DM	0.8	0.8
Predicted milk, lb/d	90.0	90.0
ME allowable	82.8	90.6
MP allowable	90.7	90.8
Predicted fat, %	3.6	3.6
Predicted true protein, %	3.0	3.1
Urea cost, mCal/d	0.4	0.1
Predicted MUN, mg/dl	13.0	13.0
Milk N/intake N	0.3	0.3
Methionine (%, req'd)	100.0	113.0
Lysine (% req'd)	98.0	112.0
Lys:Met	3.08:1	3.12:1
Rumen N balance		
Peptides (%, req'd)	108.0	113.0
Peptides + NH3 (%, req'd)	133.0	120.0

(21 kg). As described above, the optimizer function of CPM-Dairy was utilized to identify a least-cost ration that met FI guidelines (Table 5). Reformulating the ration lowered feed cost by $1.09 per cow per day and $1.51 per cwt of milk produced (Table 6). In addition to reducing vitamin and mineral supplementation, the new ration increased the starch available in the diet to promote increased microbial synthesis of MP (Table 5). Increased MP from bacterial sources enabled the ration to support 80 lb (36.4 kg) of milk while eliminating urea from the diet and reducing CP from 17.2% to 16.4% (Table 5). More efficient utilization of protein also eliminated the energy needed to excrete excess urea predicted by CPM-Dairy. Increased protein efficiency also translated to lower mean MUN levels from 13.5 to 12.9 g/dl according to the cooperative. The decrease in MUN equates to a reduction in urine-N of 0.3 oz (8.5 g) per cow per day based on Jonker's equation.[5] For an 80-cow lactating herd, this would aggregate to urine-N reduction of 1.5 lb (0.7 kg) per day and 545 lb (247 kg) per year.

Discussion

These two cases describe significant opportunities for veterinarians to become involved in the nutrition of their clients' herds. Producers' decreasing profit margins limit the interventions that are cost effective for the producer and profitable for the veterinarian. Further, the number of clients that veterinarians are able to serve continues to decrease as the dairy industry becomes consolidated into larger, more productive farms. Veterinarians are expanding the scope of their services to include worker training, milking equipment analysis, reproductive program implementation, and herd nutrition to fill needs for independent expertise in proactive disease prevention and quality control.

Feed is often the leading cost of production for dairy producers, and ration formulation is an important part of herd health and productivity.[10] This combination of

Table 4. Ingredient list of Farm B ration before and after reformulation

Farm B		
Feed Ingredient	Original	Reformulated
Corn silage (lb DM)	19.30	23.000
Triticale silage (lb DM)	8.70	4.725
Corn distillers grains	6.954	1.493
Soybean meal (47.5%)	5.195	5.389
Soybean hulls	3.313	1.991
Fine ground corn (dry)	1.565	4.911
Cane molasses	1.319	1.8
Limestone	0.627	0.697
Rolled & roasted soybeans	0.327	-
Bicarbonate of sodium susquinate	0.303	0.45
Propietary mineral mix	0.219	-
Salt	0.214	0.149
Corn gluten meal (60%)	0.205	0
Blood meal	0.205	0.731
Animal/vegetable fat blend	0.164	0.165
Urea	0.050	-
Sodium selenite	0.024	-
Rumensin 80	0.004	0.004
Vitamin E (125,000 IU/lb)	-	0.001
Vitamin ADE	-	0.010
Trace mineral mix	-	0.015
Selenium premix (.06%)	-	0.016
Alimet	-	0.036
Magnesium oxide	-	0.080
Wheat midds	-	1.991

Table 5. Farm B nutrient profile before and after reformulation.

Farm B Diet Nutrient Profiles		
Nutrient	Original	Reformulated
CP, %	17.2	16.4
RUP, % of CP	35.60	37.2
NDF, %	36.70	33.6
ForageNDF, % DM	26.7	25.9
Ether extract, %	5.50	4.1
NFC, %	33.30	39.8
Starch, %	18.10	26.5
P, %	0.36	0.4
ME, mCal/d	56.72	56.3
MP, g/d	2,240.00	2,355.0
RUP, g/d	1,157.00	1,045.0
Bacterial, g/d	1,084.00	1,310.0
NEL, mCal/lb DM	0.77	0.8
Predicted milk, lb/d	80.00	80.0
ME allowable	79.80	80.0
MP allowable	71.90	80.0
Predicted fat, %	3.70	3.7
Predicted true protein, %	3.00	3.0
Urea cost, mCal/d	0.52	0.0
Predicted MUN, mg/dl	14.00	12.0
Milk N/intake N	0.31	0.3
Methionine (%, req'd)	94.0	121.0
Lysine (% req'd)	95.0	115.0
Lys:Met	3.3:1	3.1:1
Rumen N balance		
Peptides	143.0	110.0
Peptides + NH3	143.0	117.0

traits provides veterinarians interested in providing preventative health services an opportunity to expand the dimension of their offerings, and nutrition management provides dairy practitioners the quintessential opportunity to engage the producer at a management level on a continuing and regular basis. Further, when significant cost savings can be recognized, as for these two farms, the veterinarian can more easily convey the value of his or her service and charge accordingly.

In these two case examples, ration cost and cost of production were reduced with the inclusion of a quality RUP and a rumen-protected methionine source. Producers and the nutritionists that serve them often eliminate or replace these ingredients during times of poor milk price and profitability. Microbial protein is an ideal source of amino acids for milk and milk protein synthesis, but can only support approximately 10,000 lb (4,545 kg) of milk.[13] Balancing dairy rations for cows producing 22,000 lb (10,000 kg) to 30,000+ lb (13,636 kg) of milk annually requires the inclusion of RUP to meet MP needs.[9] Increased RUP is especially critical for postpartum and peak lactation cows where DMI does not meet the MP demands of production.[14] Lysine and methionine are likely the first and second limiting amino acids for milk production, and exist in body tissue, rumen bacteria, and milk in a 3:1 ratio.[6] Therefore, dietary RUP sources should include appropriate ratios of methionine and lysine to maintain a 3:1 ratio at the small intestine. Common sources of RUP include non-ruminant blood meal, treated soybean meal, corn gluten meal or feed, distillers grains, and brewers grains. Typically, blood and soybean meals are high in lysine relative to methionine, with the other ingredients having the opposite profile.[9] Feed sources of RUP have differing levels of digestibility, with additional variability in the by-product nature of these ingredients. The inclusion of protein sources to meet lysine and methionine requirements also enables the reduction of CP levels and further reduction of environmental N excretion. As N intake increases above 0.88 lb (400 g) per day, urinary excretion of N increases exponentially.[3]

Table 6. Changes in production, cost, and environmental categories observed after intervention.

	Summary of outcomes			
	Farm A		Farm B	
Outcome	Before	After	Before	After
Test-day milk (lb)	71.8	79.0	70.0	71.2
Standardized 150-day milk (lb)	76.3	84.8	75.2	79.4
Milk fat (%)	3.7	3.4	3.3	3.4
Milk fat (lb)	2.7	2.7	2.3	2.4
Milk protein (%)	3.1	2.9	2.9	2.9
Milk protein (lb)	2.2	2.3	2.0	2.1
MUN, g/dl	12.8	9.9	13.5	12.9
N excretion, lb/cow/yr	145.5	112.5	153.4	146.6
P excretion, lb/cow/yr	46.1	43.6	39.5	33.1
Feed cost, $/cow/d	$4.99	$4.54	$5.92	$4.83
Feed cost, $/lb of dry matter	$0.10	$0.09	$0.13	$0.10

Noftsger and St-Pierre[7] fed diets differing in CP and methionine and observed increased milk yield, milk protein yield, and decreased urinary N in low CP diets supplemented with methionine, compared to low CP diets without methionine supplementation. Reformulation of the ration to include a RUP source high in lysine (blood meal) and a rumen-protected methionine source increased MP and RUP, and ensured adequate lysine and methionine supply in the appropriate 3:1 ratio.

In addition to economic sustainability, ration formulation provides veterinarians with an opportunity to address farm environmental issues. These two farms are located in the Chesapeake Bay Watershed, which has come under close scrutiny from the US Environmental Protection Agency.[8] Historically, producers have been unable or unwilling to reduce key nutrients, such as P and N, even when financially compensated for it.[11] This may be in part due to the current business model of dairy feed and ration providers. In many instances, nutritional service, including ration formulation, is provided to the dairy producer free of charge by a feed or mineral company. In order to maintain a level of profitability for the feed company, increased margins and/or increased inclusion rate of minerals is used for the ration formulation. Despite repeated published studies regarding the requirement for P supplementation, many dairy farms continue to include excess P as part of the ration.[2]

Veterinarians are uniquely positioned as independent farm service providers that integrate knowledge of nutrition, reproduction, and herd health to formulate a ration that addresses concerns at all three levels. They are well-suited to also include the impact of nutrition on their clients' nutrient management plans and environmental stewardship.

Conclusion

Nutrition continues to be one of the most influential parts of dairy farms' economic and environmental sustainability. These two farms are a small representation of the work routinely conducted by the Field Investigation Group at the University of Pennsylvania School of Veterinary Medicine. In these two cases, veterinarians were able to provide nutritional services that had significant impacts on profitability and nutrient excretion.

Endnotes

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