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Evaluating Commercial California Dairy Rations
2. Nutritional Considerations

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The dairy industry in California has been expanding, and continues to expand, at a steady rate. In addition, the milk production levels of the cows have increased steadily, even as the average size of California dairy herds has increased.

Nutritional professionals are increasingly utilizing sophisticated computer models of dairy cows to formulate rations, as well as evaluate the nutritional status of rations that are fed to dairy cows. There has been very little research conducted to critically evaluate the ability of these nutritional models to predict nutritional limitations in specific rations fed to specific groups of cows. Such studies are necessary if the accuracy of the computer models are to be assessed. This may become particularly important in the future as these models become one of our most effective tools to predict loss of nutrients in urine and feces, thereby providing a mechanism to determine the effectiveness of changes in feeding and management strategies designed to reduce the environmental impact of dairy cows. Clearly, environmental issues have grown in importance in recent years, and promises to become even more important in the future.

The objective of this study, from which the data in the article is derived, was to provide information on relationships between nutritional characteristics of rations, cow behavior, and productive performance of cows on commercial dairies in California. A previous article (posted in June 1999) examined cow behavior and rumen fermentation. This article examines the nutritional status of the rations.

Process

Four commercial dairies in the Chino, Tulare, Modesto and Petaluma areas of California were selected for evaluation. Dairies were selected that had sizes, rations and performance levels that were judged to be relatively typical of other dairies in their areas.

Over a single 24 hour period, between mid-August and early September 1998 and immediately after a DHIA test on each dairy, a high string on each dairy was evaluated. Animal behavior (% of cows eating, lying down and ruminating each hour), rumen fermentation (pH, ammonia N on 6 different cows at 6 h intervals; high string only), and parameters of body status (body weight (BW) by girth tape, body condition score (BCS) by visual assessment and body locomotion score (BLS) by visual assessment) were all determined. Dry matter (DM) intake as well as composition of the DM were also determined. In addition, milk production and composition was determined from DHIA records. Daily temperatures and humidities were also recorded hourly on all dairies for each target string of cows.

The data collected was used to better understand the way that the cows responded to hot temperatures in terms of their behavior and performance. The data was also used as input to a whole cow computer model to identify nutritional opportunities within the ration as well as evaluate the accuracy of the model itself.

The cows in Tulare were fed at about 7:00, 12:00, 16:00 and 19:30 h, those in Petaluma were fed at about 7:00 and 16:30 h, those in Modesto were fed at about 6:45 and 15:00 h, and those in Chino were fed at about 5:30 and 15:45 h. The Petaluma cows were also fed some grain in the parlor. The cows in Tulare were milked at about 8:00, 16:00 and 23:30 h, those in Petaluma were milked at about 2:00 and 13:30 h, those in Modesto were mmiled at about 3:00 and 15:00 h, and those in Chino were milked at 1:00 and 12:30 h.

Nutritional Evaluation of the Rations

The rations consumed by the cows were evaluated in the context of the nutrients expected to be required by the cows to meet their observed level of performance. This was done with an experimental computer model (SHIELD 8.7), which describes cows mathematically on the basis of known and presumed biological relationships.

Nutrient Composition of the Feedstuffs Sampled: Feedstuffs utilized in the rations were sampled on each dairy, although not all feedstuffs were sampled on each dairy. The nutrient levels of these feedstuffs were used to evaluate the performance of the cows. All feedstuff assays were completed by standard 'wet' chemical procedures and assayed values were, in general, within normal ranges.

Feedstuff Composition of the Rations Consumed: Based upon the actual mixes of feeds that were fed to each string on each dairy, as well as the dry matter content of these feedstuffs, the feedstuff composition of the actual complete diet consumed by the cows was calculated on a dry matter basis. This is in Table 1.

All high string rations included a substantial component of high quality alfalfa hay, with all dairies except Petaluma including some silage. Corn grain was the sole grain source on all dairies, except Petaluma which also utilized barley. Whole cottonseed, dried distillers grains, beet pulp, almond hulls and canola meal were used on most or all dairies. Only Petaluma made use of a high impact UIP protein premix that contained several animal and plant sources of high UIP feedstuffs. RP methionine was used on one dairy, a yeast culture product was used on two dairies, as was an RP fat.

Table 1. Feedstuff Composition of the High String Rations Consumed (% of DMI).

	Modesto	Chino	Tulare	Petaluma
Forages				
Alfalfa hay (High quality)	27.73	27.66	18.71	29.51
Alfalfa hay (Lower quality)	-	-	-	4.58
Cereal silage	-	-	13.54	-
Corn silage	9.31	8.62	-	-
Oat hay	-	-	2.65	-
Grains and Seeds				
Barley grain	-	-	-	16.97
Corn grain	26.16	18.24	14.98	22.36
Cottonseed (with lint)	7.74	10.80	8.30	12.65
Protein Meals				
Blood meal	-	-	-	0.25
Canola meal	4.96	3.34	4.47	-
Corn gluten meal	-	-	-	0.25
Cottonseed meal	-	-	-	1.27
Feather meal	-	-	-	0.25
Soybean meal	-	-	2.65	1.48
Plant By-Products				
Almond hulls	-	4.92	8.81	7.54
Beet pulp (dehy)	9.90	10.55	7.20	-
Brewers grains (dehy)	-	-	-	0.25
Citrus pulp (HM)	-	2.94	3.22	-
Distillers grains (dehy)	9.81	7.81	7.94	0.25
Wheat millrun	-	-	-	1.19
Miscellaneous Ingredients				
Fat (RP)	0.73	-	0.80	-
Fat (animal)	0.02	-	-	-
Yeast Culture	0.05	-	0.27	-
Whey permeate (liquid)	0.09	-	-	-
Water	-	-	-	0.15
Soybean waste (tofu waste)	-	1.89	-	-
RP methionine	-	-	-	0.14
Molasses	1.51	1.21	4.36	-
Vitamin/mineral/buffer pack	2.04	2.02	2.37	2.10

Nutrient Composition of the Rations Consumed: Based upon the levels of the feedstuffs in the diets consumed by the cows in on each dairy, as well as the nutrient composition of the feedstuffs in the rations, the nutrient composition of the diets consumed were calculated. Some of the most important nutrients are summarized in Table 2.

Table 2. Nutrient composition of the diets consumed.

	Modesto	Chino	Tulare	Petaluma
Dry matter (%)	69.7	62.4	64.1	52.8
Fat (% of DM)	5.2	5.5	5.2	5.2
NDF (% of DM)	32.7	31.5	33.6	28.3
NFC (% of DM)	36.7	36.6	33.9	40.2
CP (% of DM)	17.5	18.1	17.8	18.5
Soluble (of CP)	28.0	30.5	32.7	33.5
Digestible UIP (% of CP)	28.6	26.0	24.4	26.5

The nutrient levels of the diets were very similar among dairies with CP averaging about 18% of DM with about 31% of that being calculated to be rapidly soluble in the rumen. Both of these values are consistent with current recommendations. The proportion of total dietary CP calculated to be digestible UIP was consistent among dairies and averaged about 26% of total CP. This could be interpreted as being rather low relative to current recommendations. The level of NDF was similar among dairies averaging about 31% of DM, which is consistent with current recommendations. In contrast the levels of NFC were much more variable, ranging from about 34% in Tulare to 42% in Petaluma. These values are lower and higher, respectively, than current recommendations.

Nutrient Status of the Diets Relative to Predicted Animal Requirements

The observed performance of the cows on each dairy was evaluated in relationship to the nutrients levels of the diets consumed, as well as the level of intake of those diets, to determine potential nutrient deficiencies that could limit productive performance. This was done with an experimental mathematical model of dairy cows called SHIELD (version 8.7). Key factors are summarized in Table 3.

Dry Matter Intake: The maximum predicted dry matter intake of a group of dairy cows reflects everything that is known about the ration that they are consuming as well as known characteristics of their management. For this reason, actually recorded DMI should seldom reach the maximum predicted value. For all strings, only the Petaluma high string reached the maximum predicted DMI, with other groups being in the range of 75% to 94% of maximum. These lower than maximum values, which are normal, generally represent unexplained factors impacting cow comfort that suppress DMI. However, the very low value for the Modesto high string may suggest a difficulty in the predicted suppression of DM intake in SHIELD due, perhaps, to high temperatures, as these cows were observed to be in apparent heat distress for most of the daylight hours.

Table 3. Predicted Performance Parameters of Cows on all Dairies.

	Modesto	Chino	Tulare	Petaluma
Miscellaneous Parameters				
Maximum predicted DMI (lb/d)	61.3	59.0	52.8	59.3
Actually recorded DMI (lb/d)	45.9	51.3	47.0	60.0
% of maximum	74.9	86.9	89.0	101.2
Predicted MUN (mg/dl)	15.2	15.8	15.1	15.5
Predicted Net BW change (lb/d)	-0.6	3.4	-1.9	1.0
Predicted Protein Status (% of required)				
Degraded intake protein (DIP)				
Soluble	81	103	97	134
Insoluble	197	143	146	109
Intestinally absorbable	92	107	87	94
Predicted Amino Acid Status (% of intestinally absorbable requirement)				
Methionine	133	134	127	156
Lysine	100	108	107	103
Threonine	126	134	129	126
Leucine	137	136	126	128
Isoleucine	102	114	102	102
Valine	109	119	112	112
Histidine	106	104	106	106
Arginine	121	113	136	126

In spite of the relatively similar characteristics of the Modesto, Tulare and Petaluma high strings in terms of animal characteristics and milk production and composition, the measured intake of feed was much lower for the Tulare and Modesto groups. This difference was probably partly due to the higher NDF level of the Modesto and Tulare high string diets, which would reduce maximum predicted DM intake vs. Petaluma, as well as the higher discount on DMI due to the higher humidex at Modesto and Tulare.

Energy Balance: Intake of energy must, by definition, equal the output of energy. Thus any apparent difference in the energy consumed in the ration and the energy utilized for body maintenance, milk production, cow growth, growth of the fetus, heat stress and nitrogen excreted in the urine as urea must be due to changes in weight of the cows. On this basis, the high string cows in Tulare and Modesto were estimated to be losing small amounts of net body weight whereas those in Petaluma were estimated to be gaining a small amount of body weight. The substantial (3.4 lb/d) positive body weight gain of the Chino high group appears high relative to the observed body condition of the cows that was observed. The even more substantial (5.3 lb/d) gain of the Chino mid/low group cows seems implausible, whereas the small net weight gains or losses of the mid/low groups on the other dairies appear consistent with the observed body condition changes between the strings on those dairies.

The substantial predicted, but unlikely to have occurred, body weight gains of the cows in Chino, may reflect cows with lower genetic potential due to a less efficient ability to extract and utilize energy from the diet.

Protein Balance: The SHIELD outputs suggest that the intake of degraded intake protein (DIP), that was rapidly solubilized in the rumen, was closely matched to its estimated requirements. In contrast, the delivery of DIP which was estimated to be slowly degraded in the rumen was oversupplied for all strings on all dairies, except in Petaluma.

SHIELD evaluations do not suggest that the Chino string was limited by supplies of intestinally absorbable protein. In contrast, strings on the other dairies were probably limited by absorbable protein delivered to the intestinal absorptive site. This undersupply ranged from 87 to 104% of predicted requirement. Values less than 100% can be interpreted as a failure of the SHIELD program (as a requirement can be interpreted as a minimum daily supply), or that the cows in these strings were manipulating protein metabolism to maintain protein output, primarily in milk, at a level that could not be sustained by protein delivery to the intestinal absorptive site.

Amino Acid Balance: Delivery of amino acids to the intestinal absorptive site at levels less than 95% of SHIELD predicted requirements can be interpreted as a failure of SHIELD, as the animal has a limited ability to make up deficits of these essential amino acids. Delivery of amino acids at levels between 95 and 105% of requirements suggest a potential limitation while deliveries in excess of 105% suggest little likelihood of a limitation. Based upon these criteria, the SHIELD outputs suggest that lysine, isoleucine and histidine could have limited performance on at least one string among dairies.

Predicted Performance Limiters within Dairy

It is not always the case that performance of a string of cows is limited by a deficit of a nutrient. Cow comfort, genetic potential and unexplained factors also limit performance. Nevertheless, it is seldom the case that nutritional tinkering with a diet will not lead to improved performance, even though that improvement may be too small to measure.

SHIELD evaluations provide clues as to nutrients that may be undersupplied, or oversupplied, relative to predicted requirements. The following discussion is based upon the SHIELD evaluations of each of the strings evaluated on each of the four dairies. By nature it is speculative and highly dependent upon the accuracy of the rations fed to the cows and the nutrient profiles of all of their ingredients. Evaluating the past is much less difficult than predicting the future. The following speculation is not criticism.

MODESTO: Performance was primarily limited by the low DMI caused by the hot temperatures and lack of effective cooling of the cows in the drylots (i.e., low cow comfort). The levels of insoluble DIP were high and those of soluble DIP were low. Supplies of intestinally absorbable protein almost certainly limited production. Lysine and/or isoleucine may have limited performance, although the extent of such a limitation would likely have been modest. Iron appears to have been dramatically oversupplied and this could be interfering with utilization of other trace minerals, particularly if iodine and selenium were undersupplied to the extent suggested.

CHINO: There was no evident nutritional limitation to higher performance. While DMI was lower than possible, there is no evident nutritional cause for it to be so. Supplies of insoluble rumen degradable CP were high. Histidine may have limited performance, although the extent of such a limitation would likely have been modest. Mineral and vitamin status could not be assessed in this string.

TULARE: Performance was primarily limited by the low DMI caused by the hot temperatures and lack of effective cooling of the cows in the drylots (i.e., low cow comfort). The levels of insoluble DIP were high and those of soluble DIP were moderate. Supplies of intestinally absorbable protein almost certainly limited production. Isoleucine may have limited performance, although the extent of such a limitation would likely have been modest. Iron and zinc appear to have been sharply oversupplied and this could be interfering with utilization of other trace minerals. Vitamin D was supplied well in excess of currently accepted requirements.

PETALUMA: Supplies of soluble rumen degradable CP were high, and supplies of intestinally absorbable protein almost certainly limited performance. Lysine and/or isoleucine may have limited performance, although the extent of such a limitation would have been modest. Mineral and vitamin status could not be assessed in this string.

Summary

Two aspects of the management of the cows on all dairies deserve a final note. The first is that UIP delivery tended to be lower than currently accepted requirements in general and lower than SHIELD estimated requirements specifically. Opportunities for increased performance levels due to increased dietary levels of UIP are suggested.

The second aspect that appears common to all dairies is the modest apparent modifications of ration nutrient levels and ration feeding schedules due to the hot summer weather conditions. Ration modifications relative to NDF and fat levels in particular, as well as feeding rations at times of the days that cows are interested in eating them, appear to offer opportunities for increased DM intake and improved performance.

A complete report of this project is available by request from the author.

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