SELECTING DIFFERENT FEEDSTUFFS TO PROVIDE THE UNDEGRADED INTAKE PROTEIN NEEDS OF HIGH PRODUCING DAIRY COWS

by

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Our current protein feeding standards for lactating cows (NRC, 1989) include standards for ruminally undegraded intake protein (UIP) and ruminally degraded intake protein (DIP) in an attempt to optimize absorbed protein (AP). AP is derived from microbial crude protein (BCP), mostly bacterial, and UIP which pass from the rumen and are digested in the small intestine. Conceptually, this approach to describing ruminant protein needs is well founded and provides the basis to start defining amino acid (AA) requirements for lactating cows when we are able to accurately predict AA flow to and absorption from the small intestine. We decided last year (Van Horn and Powers, 1992) that we could better predict AA flow to small intestine than we could predict utilization.

Clark (1993), the previous paper, dealt with AA delivery to the small intestine, particularly with respect to optimizing BCP production. The objective of this paper is to review research directed at optimizing UIP as measured in increased milk yield obtained when feeding dietary UIP supplements.

Table 1. Rumen undegradability of protein in selected feeds.[1]

Supplement	CP %	Undegrad-ability
Alfalfa haylage	20.0	.23
Blood meal	87.2	.82
Brewers dried grains	25.4	.49
Casein	92.7	.19
Corn	10.0	.52
Corn gluten feed	25.6	.22
Corn gluten meal	46.8 or 67.2	.55
Cottonseed meal	45.6	.43
DDGS	25.0	.47
Feather meal	85.3[2]	.71
Fish meal	66.7	.60
Meat meal	54.8	.76
Meat and bone meal	54.1	.49
Soybean meal (49%)	55.1	.35

[1]From NRC (1989).
[2]From Tomlinson et al. (1993).

Byproduct protein sources are commonly available to dairy cattle because many food and fiber industries were able to market them profitably as an alternative to waste disposal. Many of these byproducts have been processed in ways that make them good UIP sources (Clark et al., 1987). Table 1 shows CP composition (DM basis) and estimated undegradability for several feedstuffs and supplements. High undegradability make blood meal, corn gluten meal, dried brewers grains, distillers dried grains with solubles, feather meal, and fish meal excellent candidates to use to increase dietary UIP. Although soybean meal (SBM) is listed in NRC (1989) with an undegradability of .35, many estimates suggest .26 is common (e.g. Tomlinson et al., 1993).

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Evaluating Milk Production Response to Dietary Protein

The response to SBM which we established some time ago still appears valid (Figure 1). Milk yield responses to supplemental protein are curvilinear with the greater response to supplementation at low protein being accounted for by increased dry matter intake (DMI). DMI response is probably due, in large part, to beneficial effects of dietary protein on total diet DM digestibility (e.g., Van Horn et al., 1979) and, hence, BCP production (Clark, 1993). Response to UIP supplements should not be expected to be any different than the response illustrated in Figure 1 except, hopefully, near maximum response should be obtained at lower levels of dietary protein. An example of a UIP supplement sparing dietary protein in this manner was found by Harris et al. (1992). This experiment utilized 50% corn silage total mixed rations (TMR) containing 14 or 18% crude protein (CP) in which hydrolyzed feather meal was the UIP supplement at 0, 3, or 6% of DM. SBM was the control source of supplemental protein. This factorial arrangement of feather meal supplementation within each protein level permitted measurement of the interaction of UIP with dietary CP level. In this experiment, that interaction existed.

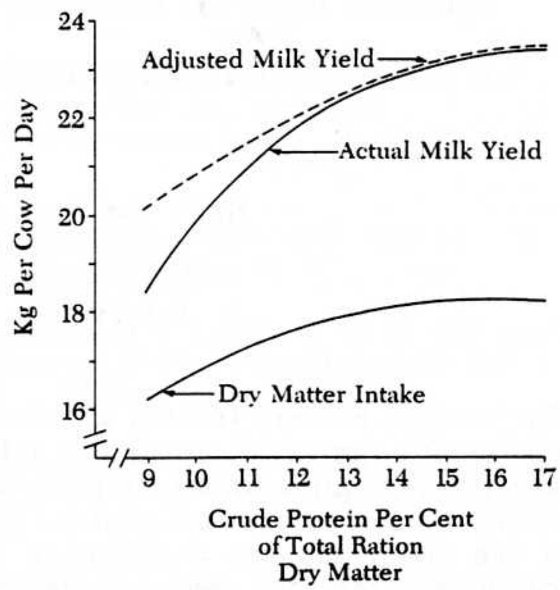

Figure 1. Milk yield and feed intake responses to increasing dietary protein with soybean meal in diets based on low-protein forages. From Van Horn et al. (1979).

Note (Table 2) that performance by cows fed the 14% CP diet containing 3% feather meal was at least as good as that obtained from higher protein diets. Although milk yield was actually highest with 3% feather meal in 14% CP diet, it is most logical to assume that performance with this diet was only equal to that achieved with 18% CP. With these data, one could surmise that a mixture of SBM and 3% feather meal optimized AP at 14% CP whereas it required higher dietary protein with all SBM (0% feather meal) which may have been degraded to a very high extent in the rumen or with 6% feather meal which may have needed more SBM than was added with 6% feather meal in 14% CP diets. With 14% CP diets, 6% feather meal probably did not supply adequate ruminal available protein for optimum BCP production.

Table 2. Interaction of milk yield response with level of feather meal and level of dietary protein.[1]

	MY[2] (lb/day) with dietary FtM of:		
	0%	3%	6%
14% CP	54.0	62.2	54.7
18% CP	57.8	57.3	57.1

[1]From Harris et al. (1992).
[2]MY = milk yield, FtM = feather meal, hydrolyzed.

Unfortunately, a second study did not show the added benefit of 3% feather meal over SBM in relatively low protein TMR (Tomlinson et al., 1993) nor have other studies shown benefit of feather meal over SBM (Moss and Holliman, 1990) or meat and bone meal (Kellems et al., 1989).

Much of the research with other UIP supplements has shown that beneficial effects were inconsistent. Table 3 shows a summary of references reviewed.

Fish meal probably has given increases in milk yield most consistently. In 20 comparisons with SBM, fish meal supplementation gave an average of 2.2 lb/cow/day increase in milk yield. However, increase in fat corrected milk (FCM) was only .35 lb/cow/day due to milk fat percent reduction in some of the studies that had the greatest increase in milk yield. For example, Spain et al. (1990) obtained reduced milk fat concentrations with fish meal. Rumen volatile fatty acid (VFA) concentrations were not significantly affected by diet, indicating that fish meal did not reduce milk fat production by altering ruminal fermentation. They hypothesized that some factor must have been present in fish meal that affected milk fat production such as residual polyunsaturated oil. The fish meal used in their study contained 8.5% ether extract. Many studies did not find reduced milk fat percentages when feeding fish meal.

Heat treated SBM (including expeller SBM) also gave an average increase in milk of 2.2 lb/cow/day in 5 comparisons with SBM-supplemented control cows. FCM response was 1.5 lb/cow daily.

Corn gluten meal (CGM) was not an effective UIP supplement. Average response in 10 comparisons with SBM-fed control cows was -.5 lb milk/day and -.4 lb FCM/day. Many CGM studies were with corn silage-based diets with which total diet corn levels were high and, consequently, diet lysine levels low due to most of the protein coming from corn sources. Diets fed by Holter et al. (1992) had considerably lower lysine content relative to lysine in milk produced which led them to conclude that lysine was the most limiting amino acid in their diets.

Responses to blood meal or a mixture meat and bone meal, blood meal, and feather meal averaged +.6 lb milk/d and +1.0 lb FCM/day in 6 comparisons with SBM. One of these studies recently completed at the University of Florida (Tomlinson et al., 1993) showed no benefit to added blood meal, however. In reviewing these results in the context of estimated AA availability for milk synthesis and in contrast to several studies where supplemental fish meal gave response in high alfalfa diets, we concluded (Van Horn and Powers, 1992) that UIP supplementation is much more likely to be of benefit in alfalfa-based diets. This more complete review of research with UIP tends to confirm this since many of the positive responses to fish meal and heated SBM were with alfalfa-based diets. A related reason may be the amount of supplemental protein needed. For example, when diets contain >40% high protein alfalfa DM, little supplemental protein is needed to bring total dietary protein percentages up to 17 to 18% CP. Small amounts of UIP perhaps could make more difference relative to SBM when supplement amounts are small than when larger amounts are fed such as with low protein forages like corn silage.

Table 3. Research with lactating cows fed UIP supplements compared to soybean meal.[1]

Reference	Dietary forage	Supplement	Comments
Broderick, 1992	Alfalfa silage	Fish meal	Two trials, MY ⇑ P<.01
Berzaghi and Polan, 1991	Alfalfa silage	Fish meal	MY ⇑ P<.01
		CGM	MY ⇑ P=?
Petit and Veira, 1991	Alfalfa silage	Fish meal	FCM ⇑ P=.12
Atwal and Erfle, 1992	Alfalfa sil., corn sil.	Fish meal	Two comparisons, MY ⇑ P<.05
Klusmeyer et al., 1991	Alfalfa sil., corn sil.	Fish meal	MY ⇑, P=.13
Bruckental et al., 1989	Corn sil., hay	Fish meal	MY NS, FM ⇓ milk fat %
Broderick et al., 1990	Alfalfa silage	Expeller SBM	Two trials, MY ⇑ P<.05
		DDGS + CGM	MY NS
Hoffman et al., 1991	Alfalfa silage	Expeller SBM	MY NS
Zimmerman et al. 1992	Alfalfa hay	Processed SBM	MY ⇑ P=?
Calsamiglia et al., 1992	Alfalfa sil., corn sil.	Expeller SBM+FM	Two trials, MY NS
Robinson et al., 1991	Alfalfa silage	CGM	Two trial, MY NS
Taylor et al., 1991	Alfalfa hay	CGM	MY NS
		CGM + BM	MY interaction x cooling
Holter et al., 1992	Corn silage	CGM	MY NS
Wohlt et al., 1991	Corn silage	CGM	MY ⇓ NS
		Fish meal	MY ⇑ NS, fat % ⇓
Winsryg et al., 1991	Corn silage	CGM-MBM	MY ⇓ NS
Spain et al., 1990	Corn silage	CGM	MY NS ⇓, fat % ⇑
		Fish meal	MY NS ⇑, fat % ⇓
DeGracia et al., 1989	Corn silage	CGM-BM	MY NS
Montysaari et al., 1989	Corn silage	Fish meal	MY NS, fat % ⇓
		MBM +	MY NS
		Blood meal+MBM	MY NS
Tomlinson et al.,	Corn silage	Blood meal	MY NS
		Feather meal	MY NS, milk protein % ⇓
Harris et al., 1992	Corn silage	Feather meal	MY ⇑, interaction with diet CP
Kellems et al., 1989	Alfalfa silage	Feather meal	MY NS
Moss and Holliman, 1990	Corn sil., alf. hay	Feather meal	MY ⇓ NS, milk protein % ⇓
Owen and Larson, 1991	Corn silage	DDGS	MY ⇑ with 19% ⇓ with 36%
McGuffey et al., 1990	Corn sil.-alf. sil.	DDG	MY ⇑ P=.06
Powers, 1993	Corn silage	DDGS	SCM ⇑, DDGS sources differed
Van Horn et al., 1985	Corn silage, alfalfa	DDGS	MY ⇓, DDGS heat damaged

[1]UIP = undegraded intake protein, MY = milk yield, FM = fish meal, CGM = corn gluten meal, SBM = soybean meal, MBM = meat and bone meal, BM = blood meal, DDGS = distillers dried grains with solubles, SCM = solids corrected milk, FCM = fat corrected milk, NS = not significant.

Responses to dried distillers grains, with or without solubles, have been variable. Probably a significant reason for variation has been the quality of grains. For example, we used distillers dried grains with solubles (DDGS) in corn silage based diets (50% of DM) as the only protein supplement (22 or 42% of DM) or with added urea to create diets of 14 or 18% CP (Van Horn et al., 1985). Milk

Table 4. Milk yield response to blood meal as a UIP supplement in corn silage-based diets.[1]

Ingredients	Experimental diets			
	SBM 15%	BM 15%	SBM 18%	BM 18%
Corn silage	50.00	50.00	50.00	50.00
Corn meal	27.98	32.05	20.77	26.27
Whole cottonseed	8.00	8.00	8.00	8.00
Blood meal		2.39		4.63
SBM (49%)	10.86	3.84	18.22	8.20
Urea		.50		.36
Minerals	3.16	3.22	3.01	2.54
TOTAL	100.00	100.00	100.00	100.00
% CP	14.90	15.04	18.33	18.53
% CP as UIP	31.9	38.7	29.8	43.3
Milk yield (lb/day)	59.8	59.1	60.5	61.2

[1]From Tomlinson et al. (1993).

yields were significantly depressed due to DDGS. We concluded poor performance probably was due to using heat damaged DDGS since the product had a charred appearance and ADIN content was 32.9% suggesting heat damage which would lower energy value and protein availability. Owen and Larson (1991) fed similar amounts of DDGS (19 and 36% of diet DM) in 14.6 and 17.7% CP diets and obtained improved milk yields compared to SBM at low protein but significant depression at high protein when 36% of diet DM was from DDGS. Grings et al. (1992), however, fed 10.1, 20.8 and 31.6% DDGS in alfalfa-based diets to increase diet CP from 16.0 to 20.3% and obtained increased milk yields with 20.8 and 31.6% DDGS. Although no comparisons were made with SBM, response to increasing dietary content of DDGS indicated high energy availability relative to the feed grains replaced.

Powers (1993) attempted to evaluate the effect of variable quality of DDGS in a recent study. Three sources of DDGS were used, one from whiskey distilling and two from fuel ethanol production (ET and ET2). The whiskey DDGS were light in color and the two ethanol DDGS sources were light and moderately dark in color. Each DDGS source and SBM were evaluated at 14 and 18% dietary protein with and without 1 or 2% blood meal included. The levels of DDGS fed were 13% of diet DM (with 14% CP) and 26% (with 18% CP). There were no significant effects of partial supplementation with blood meal. There were no detectable differences in DMI. Solids corrected milk (SCM) is an adjusted value that takes into account differences in milk composition so that production of equal energy-equivalent milk can be compared. Table 5 shows that feeding whiskey DDGS resulted 1.9 lb/day more SCM than control diets (60.7 vs. 58.8, P=.067). Also, whiskey DDGS produced 2.0 lb/day more SCM than ET2 diets (60.7 vs. 58.7, P=.115). Feeding whiskey DDGS resulted in the highest milk protein percentages of any of the treatments and significantly higher than ET and ET2 (P=.027, P=.007).

Thus, it appears that DDGS of the quality of whiskey DDGS included in diets of this experiment offers some advantage in milk yield over supplementation with SBM only and some advantage compared to the darker ethanol distillers grains

Table 5. Solids corrected milk (SCM) yield and milk protein concentration responses to variable sources of distillers dried grains plus solubles (DDGS).[1,2]

	SCM yield (lb/cow/day)			Milk protein percentage		
Supplement	14% CP	18% CP	LS mean	14% CP	18% CP	LS mean
Control (SBM)	57.3	60.2	58.8	3.14	3.18	3.16
Whiskey DDGS	58.4	63.0	60.7	3.13	3.26	3.20
Ethanol DDGS	60.2	60.3	60.3	3.15	3.13	3.14
Ethanol DDGS #2	56.4	61.0	58.7	2.95	3.08	3.02
Overall LS means	58.4	61.1	59.8	3.11	3.17	3.14

[1]From Powers (1993). This research was supported in part by Jack Daniel Distillery.
[2]CP = crude protein, LS = least squares.

(ET2) in milk yield and milk protein percentage. Digestibility measurements taken during the experiment have not yet been analyzed statistically to see if these data help account for differences in performance.

Effect of UIP on Milk Protein Percentage

In general, dietary protein has relatively little effect on milk protein percentage. However, the range of effects brought about by feeding different UIP sources probably help establish the range of effects possible. Hydrolyzed feather meal clearly had a depressing effect on milk protein percentage of .1 to .2 percentage points. This was consistent across all references cited that evaluated feather meal. Meat and bone meal and blood meal probably have little effect but the tendency is to depress milk protein as compared to SBM. Tomlinson et al. (1993) found and interaction of blood meal with dietary protein level with the depressing effect of blood meal occurring when dietary CP was 15% but not at 18%. Mantysaari et al. (1989) obtained depression but the supplement used was a mixture of meat and bone meal, blood meal, and feather meal so the effect may have been due to feather meal.

DDGS effects can be negative. Van Horn et al. (1985) found that DDGS-fed cows produced milk with .23 percentage units less protein than SBM controls. However, this was associated with heat damaged protein which decreases energy and protein availability. Decreased energy intake has been shown to depress milk protein percentage. The study of Powers (1993), Table 5, shows that good quality DDGS maintains milk protein percentage at least as well as SBM and better than darker colored DDGS. Fish meal has depressed milk protein percentage in a few experiments (e.g., Spain et al., 1990) but not consistently.

Summary

All of the UIP supplements reviewed can be utilized effectively as protein sources for lactating dairy cows. However, responses above SBM-supplemented control diets have been small and inconsistent, particularly with corn silage-based diets. CGM (corn gluten meal) appears least likely to be worth more than equivalent value of its protein and energy content in SBM and corn. With alfalfa-based diets, fish meal and heat-treated soybean products give fairly consistent responses compared to solvent SBM. DDGS responses are frequent if the quality is good (no heat damage, light in color). Blood meal, meat and bone meal, and feather meal give small or inconsistent responses and, when considering high probability of some depression in milk protein percentage, may not be worth a premium over equivalent cost of protein and energy in SBM and corn.

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