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FRED D. BISPLINGHOFF, D.V.M.
Director Technical Services

7150 ESTERO BLVD. • APT. 906
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ANIMAL PROTEIN PRODUCTS AS BYPASS PROTEIN FOR RUMINANTS

Dr. Terry Klopfenstein and Frank Goedeken
Animal Science Department
University of Nebraska-Lincoln

Accurate evaluation of protein is absolutely necessary before systems for meeting ruminant protein requirements can be used with confidence. We feel such an evaluation should be the net effects on the animal of protein degradation, protein synthesis, etc. Animal growth or production is the ultimate measure, and therefore, is the main measurement in our evaluation system. We are also suggesting practical means of using these data within the current crude protein system, but we realize that ultimately, they will be primarily used in a metabolizable or net protein system.

Our evaluation system and use of the data are based on the following points. The NRC (1984) requirements for beef cattle are generally based on rations containing silage, hay, grain and soybean meal. The proteins in these feeds are usually extensively degraded. For most beef producers, their primary choice is the supplemental protein source because they usually have the other feeds. The bypass potential of the protein supplement is the critical factor. Our evaluation system relates the value of a particular protein source to soybean meal. We have ignored finishing cattle on high grain rations because we feel sufficient evidence exists that non-protein nitrogen can meet their supplemental needs.

Bypass protein is that protein which escapes (or bypasses) digestion in the rumen. This protein is then digested in the lower tract of the animal and absorbed as amino acids to be used for productive functions by the animal. The animal has two sources of protein to use for these functions; bypass protein and microbial protein. We must always be aware of the significant role that microbial protein plays in meeting the animal's needs. In many cases, such as finishing cattle, the microbial protein is sufficient to meet the animal's needs. When the microbial protein is inadequate, the only way to supply additional protein to the animal is with bypass protein. Therefore, the value of a protein source for ruminants is highly dependent upon its bypass value. Most proteins are bypassed to some extent, but some bypass more than others. Protein broken down in the rumen supplies ammonia which can be supplied cheaper by urea.

How do we best obtain bypass values for protein sources? We can make estimates from laboratory analyses or measure bypass directly with intestinally fistulated animals. These values are useful as supporting evidence but we feel that animal growth is the best way to obtain these values. We have developed a system at Nebraska which we feel is useful (Klopfenstein et al., 1982). The system is far from perfect. Some compromises and assumptions are made and we are continually trying to improve it. Therefore, we try to be conservative in interpreting results.

Four hundred to 500 lb calves, individually fed, are used in this system. They are fed high forage-low protein rations, generally 2/3 corn silage and 1/3 corn cobs. Urea is the supplement in the control ration. Protein sources are fed at increasing levels replacing the urea. This is similar to a dose-response curve used in drug studies or in determining nutrient requirements. The increase in gain from increasing levels of protein is a direct measure of the value of that protein (figure 1). We call the gain per unit of protein fed, the protein efficiency value. Generally, the higher the amount of bypass protein, the higher the protein efficiency value.

It is absolutely essential that proteins be compared below the animal's protein requirement. Otherwise, protein is not the first limiting nutrient and valid comparisons cannot be made. Blood meal compared to soybean meal, meets the animal's protein requirement (maximum gain) with about 40% as much supplemental protein (figure 1). Therefore, blood meal is worth 2.5 times as much, per unit of protein, as soybean meal. Intestinally fistulated cattle and lab analyses support this value. Blood meal just does not degrade in the rumen while soybean meal protein is about 70% degraded.

Our current estimates of the value of the protein in several sources are presented in table 1 as percentages of soybean meal. Heating reduces rumen degradation of proteins and, therefore, the drying of blood meal and meat meal causes them to be high bypass protein sources. Our research has been conducted with ring dried blood meal. The value for old process blood meal (200%) is calculated and based on differences in amino acid availabilities in monogastrics. Meat meal is somewhat more variable than blood meal but is often an economical bypass protein source because of price and the content of phosphorus.

Feathers are a keratinous protein source of low nutritional value in their native state. Steam and pressure processing increase protein availability. Even though the protein in processed feather meal is highly digestible, its use in monogastric diets is limited due to amino acid deficiencies. As a result, feather meal is priced at about 2/3 the price of soybean meal but it contains twice the protein.

Results from a digestion study (table 2) indicate no differences in dry matter or total tract nitrogen digestion as affected by urea, soybean meal (SMB); blood meal (BM), corn gluten meal (CGM) or feather mean (FthM) supplementation. These data indicate that feather meal protein is as digestible as the other protein sources (Goedeken et al., 1987). Laboratory estimates also suggest high protein escape. Performance of steers in a growth trial (figure 2) indicates that calves consuming BM, FthM, or BM + FthM gained faster than steers fed urea. The improved protein efficiency for BM + FthM compared to either fed alone may be due to sulfur amino acids supplied by the FthM and lysine and/or other amino acids, supplied by blood meal.

These data indicate that feather meal is high in bypass protein (69% of total protein), is digestible and can be utilized in growing ruminant diets. The utilization of the FthM protein may be increased when fed in combination with blood meal possibly due to a complimentary effect of amino acids.

A summary of six experiments with ten comparisons of mixtures of bypass proteins is shown in table 2. Meat meal, blood meal and dehydrated alfalfa were sources of lysine and corn gluten meal was the source of sulfur amino acids. The average response of the combinations was 30.2% greater than that obtained with the sources fed alone. The calculated flows of metabolizable amino acids, based on those of Burroughs et al (1974), indicated that lysine (as a percent of metabolizable protein) needed to be above 7.0% and methionine above 2.1%. This is in agreement with the values of Burroughs et al (1974) (requirement of 7.2 and 2.1%, respectively).

RATION FORMULATION

Several systems which account for bypass protein have been proposed. A comprehensive system will eventually be developed which will more accurately formulate rations. At the present time, accurate values of feedstuffs and animal requirements are being developed but seem not to be ready for widespread use.

Currently used protein systems reflect values developed primarily with soybean meal (SBM). We would propose using the present system with the incorporation of SBM equivalent values (SBME). This can be readily programmed into most computers. Presently, most computer programs have constraints on urea use. This can be replaced by a SBME requirement. In a growing beef ration where no urea is presently used, the natural protein requirement would be equal to the crude protein requirement. In a ration where 1% urea is currently allowed, the SBME requirement would be 2.81 percentage units less than the crude protein requirement. The SBME value for all feedstuffs would be equal to the crude protein value except for protein sources that have been specifically tested The SBME value for old process blood meal, for example, would be 83% x 2 = 166% SBME. Urea would be zero. The computer then balances for both crude protein and SBME. Once the SBME requirement is met, urea is used to complete the crude protein requirement (table 4).

Three computer formulated rations are shown in table 5. An all natural 40% protein supplement using SBM is shown which had ingredient costs of $167/ton. A comparable supplement using bypass sources cost $91/ton. If our assumptions are correct, the two supplements are equal in feeding value. An 80% supplement using bypass sources, corn gluten meal, meat meal and blood meal, cost $171/ton. Using 1/2 the amount of supplement to meet the same supplemental protein needs as the 40% SBM supplement would cut the cost to the beef producer nearly in half.

The high protein content of blood meal, and to some extent meat meal, aids in formulating the high protein, high bypass supplements. The midds entered these supplements as a carrier. Economics favor minimizing the amount of carriers.

The advantages of using the bypass protein system are as follows: (1) The amount of natural protein fed is reduced; (2) The use of urea is increased; (3)

This results in lower cost of supplementation; and (4) Performance is maintained. Assuming that the animal's protein requirement was met on the previous "all natural" supplement, performance could not be increased, it could only be done at a lower cost.

Amino acid content of the bypass proteins and rumen degradable protein content are not accounted for in this supplement formulation system. As a generalization, type of protein source should probably be restricted to 60% of the bypass protein (or SBME) in any given supplement. Until more information is available on amino acid composition of rumen bypass protein, we cannot be more definitive. This suggests that a minimum of 40% of the bypass protein should be supplied by blood meal or meat meal.

ANIMAL PROTEINS IN LIQUID SUPPLEMENTS

Liquid supplements have previously been based on urea and a liquid carrier, primarily molasses. In the past few years, xanthan gums and clay have been used to suspend small particles such as limestone in liquid supplements. Because of the need for bypass protein in many situations where liquid supplements are used and because of the high protein content and high bypass value of blood meal, we attempted to suspend blood meal in a liquid supplement. The supplement contained molasses, condensed whey to supply rumen degradable protein, urea, vitamins and minerals. Blood meal was included as 230 lb/ton of as is supplement (55% dry matter; 32% crude protein) to supply 30% of the crude protein equivalent. Meat meal was more difficult to suspend. A similar supplement was produced where meat meal protein replaced 1/3 of the blood meal protein.

An experiment was conducted to evaluate these liquid supplements using growing calves fed a base ration of 1/2 corn silage and 1/2 corn cobs. The blood meal, meat meal and a control urea supplement were each fed in a lick tank and mixed into the ration. Also a dry soybean meal control supplement was mixed in the ration. Each of the 7 treatments was fed to 4 pens of calves.

Initially, the blood meal and meat meal supplements were consumed at levels higher than desired. Therefore salt was added to limit intakes from the lick tanks. This does demonstrate that palatability of the liquid supplements was <u>increased</u> by replacing urea with blood meal and meat meal.

Calves gained more on the supplements containing soybean meal, blood meal and meat meal than the urea controls (table 6). The calves gained the same whether fed the urea supplement in the ration or from the lick tanks. The treatment coefficients of variation indicate the variability in gains among calves within pens on each treatment and reflect variations in intakes of the liquid supplements from the lick tanks. Calves fed the blood meal and meat meal supplements gained slightly faster, had slightly higher supplement intakes and slightly higher protein efficiency values when fed from the lick tanks compared to the supplements being mixed into the ration. Coefficients of variation were not increased suggesting uniform intakes by cattle within pens.

In a second experiment, meat meal was suspended in a liquid as the only source of bypass protein. Some settling occurred in the lick tanks. During the first 44 days of the trial, the calves did not consume the liquids from the lick tanks at the desired level and it was necessary to reduce the salt level to obtain adequate intakes. This low supplement intake at the time of highest protein need by the calves, adversely affected performance (table 7).

A third experiment has been conducted to confirm the results of the first liquid supplement experiment. Calves were fed an NPN control liquid or a bypass liquid (table 8) mixed in the ration or the bypass liquid from lick tanks. Blood meal and corn gluten meal were used as the bypass protein sources.

Performance on the bypass liquid was excellent and significantly better than the urea control (table 9). The bypass liquid was initially offered in the lick tanks without added salt. As intake of the liquid increased, salt was added to restrict intake. It was necessary to add 6% salt (wet supplement basis) to limit intake to the desired level. The high consumption early in the experiment enhanced gains slightly.

Finally a growth trial using 93 growing calves was conducted to determine the performance of calves fed either a urea liquid fed in the diet or feather-blood meal combination (50% feather meal protein and 50% blood meal protein) fed in the diet or a lick tank. Lick tanks were set to meter a similar amount of supplement as that fed in the diet each day. The basal diet composition was 76.4% ensiled corn cobs and 23.6% alfalfa (dry matter basis). Urea or feather-blood meal (Fth-BM) supplement (table 10) was fed at approximately 2 lb/head/day. The Fth-BM was fed either mixed in the diet or in a lick tank.

Daily gain was similar for Fth-BM fed in the diet or lick tank and daily gain tended to be improved for either of the Fth-BM treatments compared to urea (table 11). Variation in gain was determined for all the animals within a treatment using coefficient of variation (CV) to estimate the variation between animals in protein supplement intake. The CV intended to be lower for Fth-BM fed in a lick tank indicating that protein intake of each animal was acceptable. The overall CV among pens was 10.8. Supplement intake for pens was the same for all treatments as this was fixed throughout the trial. The feed efficiency was improved when Fth-BM was fed compared to urea ($P<.10$).

Data from these four trials indicate that bypass proteins can be successfully suspended in liquid supplements. Also, these supplements are more palatable than urea control liquids. Adjusting palatability to obtain good early consumption appears to be important. Calf performance has been excellent when supplement intakes have been appropriate. Variation in calf performance which is a reflection of variation in intake from the lick tanks has not appeared to be a problem, however, these cattle were confined to pens and extrapolating to grazing situations cannot be done until grazing studies are completed.

Table 1. Bypass estimates of protein sources.

Protein source	% Protein Escape (bypass)[a]		
	Duodenal collection	Animal growth	Generalized[b] value
Soybean meal	24.6	30	1
Blood meal	82.4	84.6	2.5
Blood meal[c]	----	----	2
Meat meal	63.9	61.8	2
Corn gluten meal	60.3	57.9	2
Dehydrated alfalfa	50.8	54.8	1.5
Distillers grains	54.3	60.6	2
Distillers grains plus solubles	48.6	43.8	1.6
Brewers Dried Grains	55.0	56.4	1.8
Blood meal/corn gluten meal			2.5
Feather meal			2

[a]From Poos-Floyd et al.
[b]By authors, value relative to SBM.
[c]Old process, value based on reduced protein digestibility in nonruminants.

Table 2. Protein solubility[a], degradability[a] and digestibility.

Item	Protein source			
	Soybean meal	Blood meal	Corn gluten meal	Feather meal
Solubility[b]	28.4[c]	12.5[d]	14.2[d]	21.5[e]
Degradability	73.4[c]	17.2[d]	19.6[d]	30.9[e]
N digestion[f], %	66.6	65.8	67.1	68.4

[a]Expressed as % of protein.
[b]Solubility in vitro in phosphate buffer.
[cde]Differ P<.05.
[f]Ration N digestibility by lambs.

Table 3. Gain Response to Mixtures of Bypass Protein[a].

Protein Sources	Gain Response[b]	Reference
Corn gluten meal/Dehydrated alfalfa	37%	Rock et al., 1983
Corn gluten meal/Dehydrated alfalfa	6%	Rock et al., 1983
Corn gluten meal/Blood meal	48%	Stock et al., 1981
Corn gluten meal/Meat meal	121%	Stock et al., 1981
1/3 Corn gluten meal/2/3 Blood meal	31%	Brown, 1983
2/3 Corn gluten meal/1/3 Blood meal	27%	Brown, 1983
1/3 Corn gluten meal/2/3 Meat meal	0	Brown, 1983
2/3 Corn gluten meal/1/3 Meat meal	28%	Brown, 1983
Corn gluten meal/Blood meal	19%	Klopfenstein et al., 1984
Corn gluten meal/Meat meal	-15%	Klopfenstein et al., 1984
ave.	30.2%	

[a]Aines et al., 1985.
[b]Gain Response - Protein gains minus urea gains. Mixtures divided by weighted means of protein sources fed alone.

Table 4. Bypass Supplement Using Soybean Meal Equivalent (SBME).

Ingredient	% of Supp.	% CP	lb CP	% SBME[a]	lb SBME
Dehy 20	39.0	20	7.8	30	11.7
Meat Meal	34.0	51	17.3	92	31.2
Blood Meal[b]	14.0	83	11.6	166	23.2
Urea	9.7	281	27.3	0	0
Min.	3.3	-	--	-	--
			64		64

[a]Crude protein times relative protein value (table 4).
[b]Old process.

Table 5. "All Natural" Beef Supplements[a].

Normal 40%		Bypass 40%		Bypass 80%	
SBM	87.4%	Meat Meal	15.0%	Meat Meal	40.6%
Midds	6.2%	Feather Meal	8.8%	Feather Meal	23.9%
Min	6.4%	Midds	69.6%	Midds	21.0%
		Urea	5.2%	Urea	14.1%
		Min	1.4%	Min	.4%
$167/ton		$91/ton		$171/ton	

[a]Prices: SBM, $181; Meat Meal, $206; Feather Meal, $186; Urea, $215; Midds, $48.

Table 6. Suspended Liquids In Mixed Rations Versus Lick Tanks.

Item	Soybean Meal	Urea		Blood Meal		Blood meal-Meat meal	
		Mixed	Lick Tank	Mixed	Lick Tank	Mixed	Lick Tank
Daily intake, lb:							
Total	17.16	16.02	15.18	15.45	15.62	15.62	15.62
Supplement[a]	2.51	2.3	1.96	2.27	2.97	2.24	2.57
Daily gain, lb[b]	2.29	1.80	1.78	2.11	2.31	2.05	2.13
Feed/Gain[b]	7.14	8.33	9.09	7.69	6.67	7.69	7.14
Coefficient of variation[c]	14	12	16	15	15	18	16
Protein efficiency[d]	.47	----	----	.69	.92	.55	.72

[a]Interaction of protein source and method of feeding (P=.001).
[b]Urea vs blood meal and bloodmeal - meatmeal (P=.001).
[c]Coefficient of variation of gains within pens.
[d]Protein efficiency = (Test protein daily gain) - (Urea daily gain) Daily protein intake above urea controls.

Table 7. Meat Meal and Blood Meal In Suspended Liquids.

Item	Soybean meal	Urea	----Blood Meal---- Mixed	Lick Tank	-----Meat Meal----- Mixed	Lick Tank
Daily intake, lb:						
Total	15.53	15.33	15.75	15.41	16.21	14.65
Supplement (101 day)	2.53	2.50	2.49	2.25	2.65	2.15
Supplement (44 day)	2.01[a]	1.93[a]	2.35[b]	1.43[c]	2.49[b]	1.51[c]
Daily gain, lb (101 day)	2.02[a]	1.55[b,c]	1.75[a,c]	1.57[b,c]	1.57[b,c]	1.41[b,c]
Daily gain, lb (44 day)	1.99[a]	1.60[b,c]	2.04[a]	1.59[b,c]	1.75[a,c]	1.46[b,c]
Feed/gain	7.69[a]	9.83[b,c]	8.94[b]	9.50[b,c]	10.21[c]	10.33[c]
Coefficient of variation	13.04	22.89	20.07	27.66	17.42	21.05
Protein efficiency[d]	.439	-----	.497	.023	.043	-.313

[a,b,c]Means with different superscripts differ (P<.05).
[d]Protein efficiency = (Test protein daily gain) - (Urea daily gain) divided by daily protein intake above urea controls.

Table 8. Bypass Supplement Composition.

Ingredient	NPN control % dry matter	Bypass liquid % dry matter
Molassses	49.77	36.86
Urea	8.60	4.95
Steep Liquor	30.00	30.00
Blood Meal	-----	6.26
Corn Gluten Meal	-----	8.45
Minerals and Vitamins	-----	13.48
Xanthan Gum	.20	.20

Table 9. Bypass Liquid Supplements for Growing Calves[a].

Item	NPN Supplement	---Bypass liquid--- Ration	Lick tank
Daily Feed, lb	14.0	14.8	15.0
Daily Gain	1.20[c]	1.52[d]	1.59[d]
Feed/Gain	12.1[c]	9.9[d]	9.5[d]
Supp. Intake, lb	1.78[c]	1.88[c]	3.02[d]

[a]525 lb. initial weight.
[b]68 days.
[c,d]Means within rows with unlike superscripts are different (P<.05).

Table 10. Supplement composition[a].

Ingredient	Urea	Feather meal + blood meal
	---------- % ----------	
Water	14.39	14.39
Molasses	30.46	22.74
Blood meal		5.68
Feather meal		5.68
Trace mineral	.19	.19
Vitamin	.06	.06
Ammonia polyphos	6.37	6.37
Condensed whey	36.54	36.54
Urea liquor	9.99	6.35
Limestone	1.85	1.85
Xanthan gum	.14	.14

[a]As fed basis.

Table 11. Feedlot growth trial comparing urea to feather meal-blood meal fed in the diet or lick tanks.

	Treatment		
Item	Urea	Fth-BM[a]	Fth-BM[a] lick tank
Initial weight (lb)	527	522	523
Daily intake (lb)	15.5	14.8	15.5
Daily gain (lb)	.96[b]	1.10[bc]	1.17[c]
CV[d]	40.5	47.0	29.7
Supplement intake (lb/d)	2.0	2.0	2.0
Feed/Gain[e]	15.9[b]	13.5[c]	13.2[c]

[a]Fth-BM is a 50% mixture of feather meal and blood meal on a protein basis.
[bc]Means with different superscript differ (<.10).
[d]Coefficient of variation of animals within pens, overall CV was 10.8.
[e]Feed/gain was analyzed as gain/feed. Reported to the reciprocal of gain/feed.

Figure 1. Natural Protein Fed/Day vs Daily Gain Above Urea Control (Stock et al, 1980)

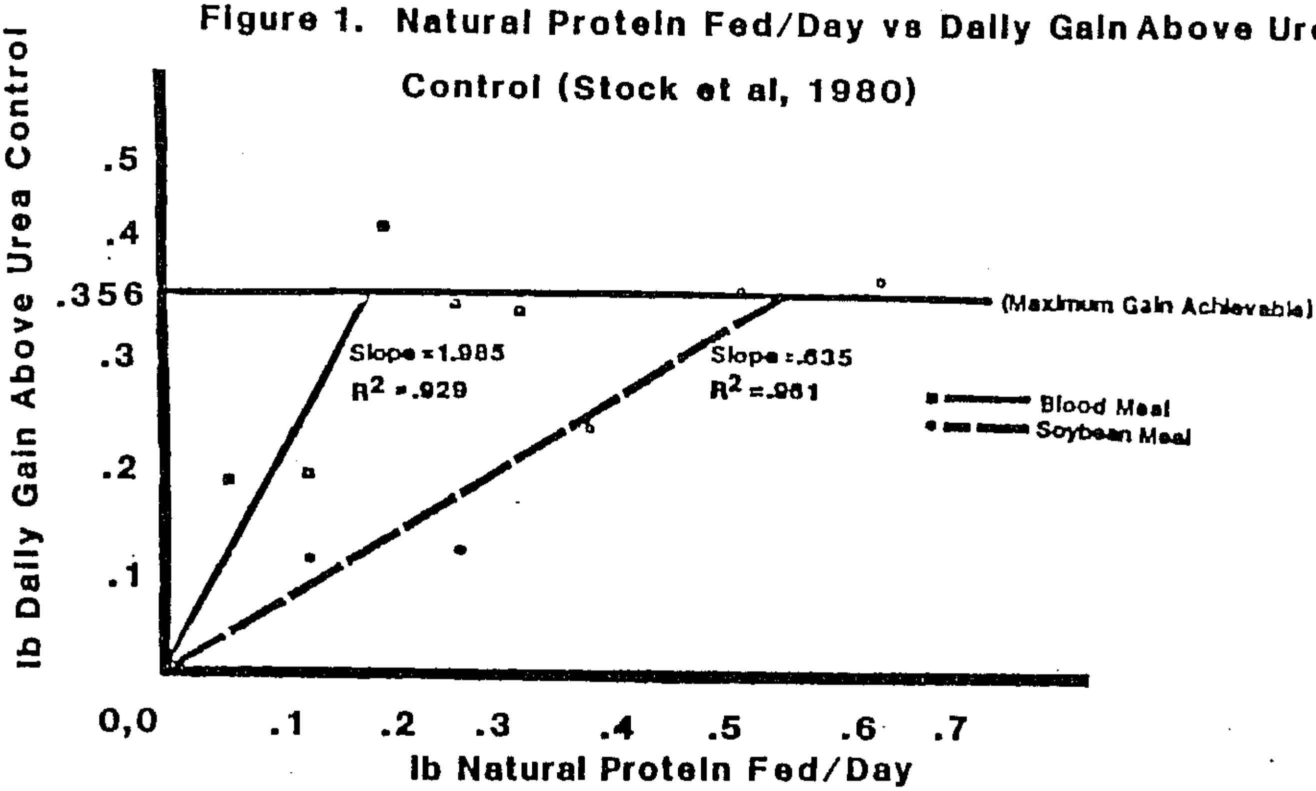

Figure 2. Steer Gain Response to Graded Levels of Feather Meal, Blood Meal and Feather + Blood Meal.