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These authors do an excellent job of discussing Animal Protein Products as BY-PASS PROTEIN sources for ruminant formulations. This article is a yeoman's effort to tie a very difficult area into a meaningful package.

Animal protein products:

Bypass potential

By Terry Klopfenstein and Frank Goedeken, University of Nebraska-Lincoln

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.

For finishing cattle, microbial protein is usually sufficient to meet the animal's needs. However, when microbial protein is inadequate, the only way to supply additional protein to the animal is with bypass protein. 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. Therefore, the value of a protein source for ruminants is highly dependent upon its bypass value.

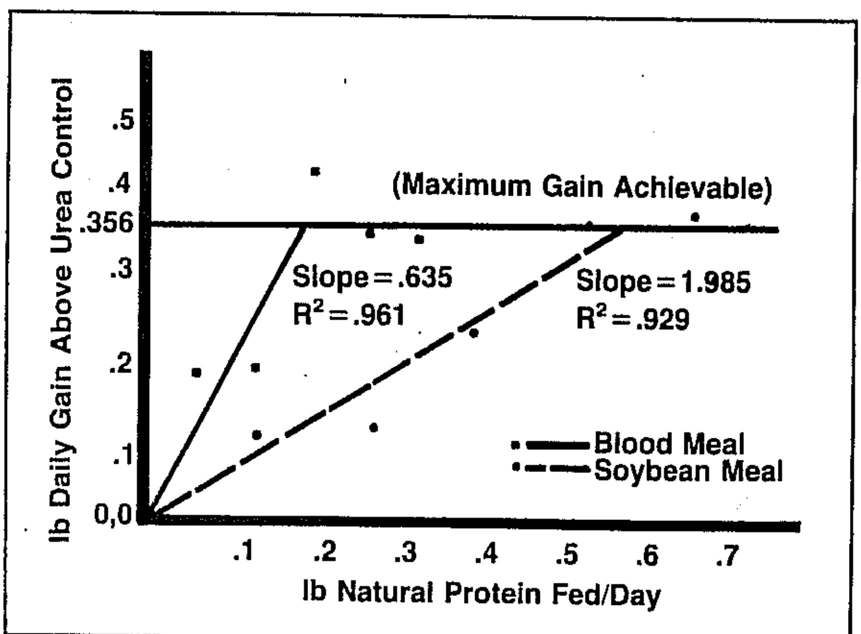

Figure 1. Natural protein fed per day vs daily gain above urea control (Stock *et al.*, 1980).

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. Lab estimates 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 ⅔ corn silage and ⅓ corn cobs. Urea is the supplement in the control ration. Protein sources are fed at increasing levels, replacing the urea. 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.

Proteins must be compared at levels below the animal's protein requirement. Otherwise, protein would not be the first limiting nutrient and valid comparisons could not 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 industrial drying of blood meal and meat meal causes them to be high bypass protein sources. Our research has been conducted with modern "ring dried" or "flash 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 phosphorus content.

Table 1. Bypass estimates of protein sources.

Protein source	Percent 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]	—	—	2.0
Meat meal	63.9	61.6	2.0
Corn gluten meal	60.3	57.9	2.0
Dehydrated alfalfa	50.8	54.8	1.5
Distillers grains	54.3	60.6	2.0
Distillers grains plus solubles	48.6	43.8	1.8
Brewers dried grains	55.0	56.4	1.8
BM/CGM			3
ZnSBM			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.

The amino acid profile of bypass protein is an important criterion in the evaluation of sources for practical diets (Sniffen and Hoover, 1978). Combination of two slowly degraded protein sources (blood meal or meat meal and corn gluten meal) improved performance of steers above the weighted average of the two individual sources (Table 2, p. 14). This may be due to an improved amino acid pattern reaching the lower tract. Methionine and lysine have been shown to be limiting in ruminant rations (Richardson and Hatfield, 1978). Blood meal and meat meal contain high levels of lysine (NRC, 1976), with corn gluten meal somewhat deficient. Higher levels of methionine in corn gluten meal could offset any deficiency of that amino acid.

Table 3 (p. 15) shows a summary of six experiments with ten comparisons of mixtures of bypass proteins. Meat meal, blood meal and dehydrated alfalfa were sources of lysine. 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 the lysine (as a percent of metabolizable protein) needed to be above 7.07% and methionine above 2.1%.

Ration formulation

A comprehensive system describing bypass protein will eventually be developed which will more accurately formu-

Table 2. Mixtures of bypass proteins for growing calves[a].

Protein Source	Daily gain, lb	Gain-urea[b], lb	Expected gain[c]	%[d]
Urea	1.49			
Corn gluten meal	1.65	.161		
Meat meal	1.68	.191		
Blood meal	1.69	.202		
CGM/MM[e]	1.73	.234	.176	133
CGM/BM[e]	1.78	.286	.182	157

[a]Ration 60% corn silage, 30% corn cobs and 10% supplement, fed as % of body weight.
[b]Daily gain of test proteins minus daily gain of urea control cattle.
[c]Numerical average of the two appropriate test proteins fed alone.
[d]Achieved gain as a percent of expected gain.
[e]50:50 mix on a protein basis.

late rations. At present, 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. We would propose using the present system with the incorporation of soybean meal equivalent values (SBME). This can be readily programmed into most computers. Most beef ration computer programs include constraints on urea use. This can be replaced by a SBME requirement. In a beef grower 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 (p.16). An all-natural 40% protein supplement using SBM had ingredient costs of $150/ton. A comparable supplement using bypass sources costs $97/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, costs $160/ton. Using one half 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 high protein, high bypass supplements. The dehy entered these supplements primarily as a carrier. Economics currently favor minimizing the amount of carriers.

Some of the advantages of using the bypass protein system include:

- The amount of natural protein fed is reduced,
- The use of urea is increased, resulting in lower cost of supplementation,
- 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 achieved 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. Generally, type of protein source should probably be limited 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.

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Table 3. Gain Response to mixtures of bypass protein.

Protein sources	Gain response[a]	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
⅓ Corn gluten meal-⅔ Blood meal	31%	Brown, 1983
⅔ Corn gluten meal-⅓ Blood meal	27%	Brown, 1983
⅓ Corn gluten meal-⅔ Meat meal	0	Brown, 1983
⅔ Corn gluten meal-⅓ 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]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
Minerals	3.3	—	—	—	—
Total			64		64

[a]Crude protein times relative protein value (Table 1).
[b]Old process.

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 at 230 lb/ton as a 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 one-third of the blood meal protein.

An experiment was conducted to evaluate these liquid supplements using growing calves fed a base ration of one-half corn silage and one-half 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 seven treatments was fed to four 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 *increased* 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, p.18).

A third experiment was conducted to confirm the results of the first liquid supplement experiment. Calves were fed an NPN control liquid or a bypass liquid (Table 8, p.18) mixed in the ration (Table 9, p.18) or the bypass liquid from lick tanks. A mixture of blood meal and corn gluten meal was used as the bypass protein source.

Performance on the bypass liquid was excellent and significantly better than the urea control (Table 10, p.18). 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.

Data from these trials indicate that bypass proteins can be successfully suspended in liquid supplements. Also, these supplements are more palatable than urea control liquids. Adjusting pal-

Table 5. "All-natural" beef supplements[a].

Normal 40%		Bypass 40%		Bypass 80%	
SBM	89.4%	Gluten meal	2.9%	Gluten meal	11%
Midds	3.2%	Meat meal	18.1%	Meat meal	38.1%
Minerals	7.4%	Blood meal	2.1%	Blood meal	8.7%
		Midds	68.5%	Midds	20.5%
		Urea	5.6%	Urea	16.1%
		Minerals	2.8%	Minerals	5.6%
$150/ton		$97/ton		$180/ton	

[a]Prices per ton: SBM, $155; meat meal, $160; blood meal, $295; urea, $210; midds, $61; corn gluten meal, $225.

Table 6. Suspended liquids in mixed rations vs 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[bc]	7.14	8.33	9.09	7.69	6.67	7.69	7.14
Coefficient of variation[d]	14	12	16	15	15	18	16
Protein efficiency[e]	.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]Statistical analysis conducted as gain/feed. Reported feed/gain is reciprocal of gain/feed.
[d]Coefficient of variation of gains within pens.
[e]Protein efficiency equals test protein daily gain, minus urea daily gain, divided by daily protein intake above urea controls.

Table 7. Meat meal and blood meal in suspended liquids.

Item	Soybean meal	Urea	Blood meal Mixed	Blood meal Lick tank	Meat meal Mixed	Meat meal Lick tank
Daily intake, lb:						
Total	15.53	15.33	15.75	15.41	16.21	14.65
Supplement (101 d)	2.53	2.50	2.49	2.25	2.65	2.15
Supplement (44 d)	2.01[a]	1.93[a]	2.35[b]	1.43[c]	2.49[b]	1.51[c]
Daily gain, lb (101 d)	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 d)	1.99[a]	1.60[b,c]	2.04[a]	1.59[b,c]	1.75[a,c]	1.46[b,c]
Feed/gain, lb	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 equals test protein daily gain, minus 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
Molasses	49.77	36.86
Urea	8.8	4.95
Steep liquor	30	30.00
Blood meal	—	6.26
Corn gluten meal	—	8.45
Minerals and vitamins	—	13.48
Xanthan gum	.20	.20

Table 9. Ration composition.

Ingredient	% of dry matter
Corn silage	45.32
Wheat straw[a]	21.00
Corn stover	21.00
Supplement[b]	12.68

[a]Ammoniated (3%).
[b]Not mixed in ration when fed in lick tanks.

Table 10. Bypass liquid supplements for growing calves[a].

Item	NPN supplement	Bypass liquid Ration	Bypass liquid Lick tank
Daily feed, lb	14.0	14.8	15.0
Daily gain[b], lb	1.20[c]	1.52[d]	1.59[d]
Feed/gain, lb	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 11. Protein solubility and degradability[a].

Item	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]
Degradability of slowly degradable fraction[f]	62.8[c]	3.1[d]	13.8[e]	6.9[de]

[a]Expressed as percent of protein.
[b]Solubility in vitro in phosphate buffer.
[cde]Differ $P < .05$.
[f]100 minus [100 times protein remaining after 12 hours of in situ incubation (crude protein-soluble)].

atability 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.

Feather meal for ruminants

Feathers are a 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 two-thirds the price of soybean meal but it contains twice the protein.

Incubation time of 12 hours was used to determine the bypass value of blood meal, corn gluten meal and soybean meal (Table 11). Seventy-three percent of the soybean meal was degraded—comparable with rumen degradation values previously reported. Ruminal protein degradation was highest for soybean meal and lowest for corn gluten meal and blood meal with feather meal intermediate. Feather meal contains a soluble protein fraction that is probably rapidly degraded in the rumen, and a protein fraction which is slowly degraded in the rumen. The relatively slow degradation of corn gluten meal compared to previous data (40% degradation) may be due to inherent difficulties with using corn gluten meal in the dacron bag technique. Researchers have reported that a gelatin mass caused by the sugars present in corn gluten meal blocks the pores in the nylon bag and reduces protein disappearance.

Results from a digestion study (Table 12, p.22) indicate no differences in dry matter or "total tract" nitrogen digestion as affected by type of protein supplementation. These data indicate that feather meal protein is as digestible as

Table 12. Intake and digestion by lambs of diets containing urea, soybean meal, blood meal, corn gluten meal and feather meal.

Item	Urea	Soybean meal	Blood meal	Corn gluten meal	Feather meal
Dry intake, lb/day	1.7	1.7	1.6	1.7	1.7
Dry matter digestion, %	54.6	56.2	58.5	58.8	57.1
N intake, lb/day	.03	.03	.03	.03	.03
N digestion, %	67.3	66.6	65.8	67.1	68.4

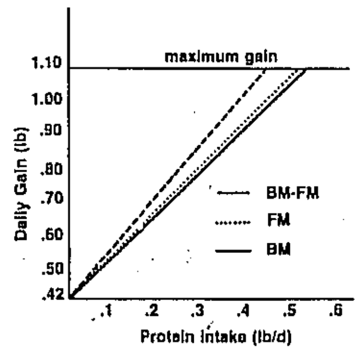

Figure 2. Steer gain response to graded levels of feather meal, blood meal and feather plus blood meal.

the other protein sources.

Performance of steers in a growth trial (Figure 2) indicates that calves consuming blood meal plus feather meal, gained faster than steers fed urea. The improved protein efficiency for blood meal plus feather meal compared to either fed alone may be due to sulfur amino acids supplied by the feather meal and lysine 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 feather meal protein may be increased when fed in combination with blood meal possibly due to a complimentary effect of amino acids. **FM**

References

Brown, W.F. 1983. Computer simulation of animal and plant growth and their interactions in a grazing situation. Ph.D. Dissertation. University of Nebraska-Lincoln.

Burroughs, W., A.H. Trenkle and R.L. Vetter. 1974. Metabolizable protein (amino acid) feeding standard for cattle and sheep fed rations containing either alpha-amino or non-protein nitrogen. A.S. Leaflet R190. Iowa State University.

Klopfenstein, T., R. Britton and R. Stock. 1982. Nebraska growth system. In: Protein Requirements for Cattle: Symposium, F.N. Owens, Ed., Oklahoma State University, Stillwater, OK.

Klopfenstein, T.J. and S.K. Wimer. 1984. Unpublished data.

NRC. 1976. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. Fifth Revised Ed. National Academy of Sciences—National Research Council, Washington, D.C.

Richardson, C.R. and E.E. Hatfield. 1978. The limiting amino acids in growing cattle J. Anim. Sci. 46:740.

Rock, D.W., T.J. Klopfenstein, J.K. Ward, R.A. Britton and M.L. McDonnell. 1983. Evaluation of slowly degraded proteins: dehydrated alfalfa and corn gluten meal. J. Anim. Sci. 56:476.

Sniffen, C.J. and W.H. Hoover. 1978. Amino acid profile of dietary bypass protein and its importance to ruminants. Proc. 33rd Distillers Feed Conf.

Stock, R., N. Merchen, T. Klopfenstein and M. Poos. 1981. Feeding value of slowly degraded proteins. J. Anim. Sci. 53:1109.

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