# USE OF ANIMAL PROTEIN BY-PRODUCTS FOR FEEDING DAIRY CATTLE

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## Introduction

Protein is the principal constituent of the organs and soft structures of the animal body. Studies within the last decade have greatly increased our knowledge concerning protein nutrition in high producing dairy cows. From these studies we have learned that, during certain stages of production, ruminants have need for protein or amino acids in excess of that provided by microbial protein synthesis and the normal escape of dietary proteins from the rumen. The distinguishing feature of proteins as compared to other nutrients is their amino acids profile.

Amino acids are classified as essential and non-essential in animal nutrition due to the fact that some can be synthesized during metabolism from certain carbohydrate residues plus amino acid molecules. Those amino acids that can be synthesized in the body are labeled non-essential. Even so, all amino acids are essential to the animal. In ruminant animals, all amino acids are synthesized by the established bacteria and protozoa population in the rumen.

The absorption of essential amino acids from digested protein is vital to the maintenance, reproduction, growth and lactation of dairy cattle. These essential amino acids must come either from dietary protein that escapes rumen fermentation or from the microbial protein produced in rumen fermentation (Figure 1).

As milk production per cow increases, it becomes more and more important that dietary protein escape rumen degradation during the fermentation process. Such protein is described as escape, protected, or bypass protein. As the name implies, it is the protein that has escaped breakdown in the rumen and arrives at the small intestine. In general, feeds contain both true protein and nonprotein nitrogen (NPN). True protein is those protein molecules composed of amino acids. The NPN fraction is essentially all converted to ammonia in the rumen. Some of the NPN fraction as well as ammonia arising from ruminal breakdown of true protein is utilized by bacteria to synthesize bacteria protein. The NPN fraction not utilized is absorbed into the blood stream and excreted by the animal or recycled in body fluids such as saliva.

About 40% of the true protein in feed escapes degradation in the rumen and reaches the small intestine. Under most production situations, the microbial protein synthesized in the rumen plus the escape of dietary protein is adequate to meet the protein requirements of animals. However,



Presented at the 28th Florida Dairy Production Conference, Gainesville, April 9-10,1991

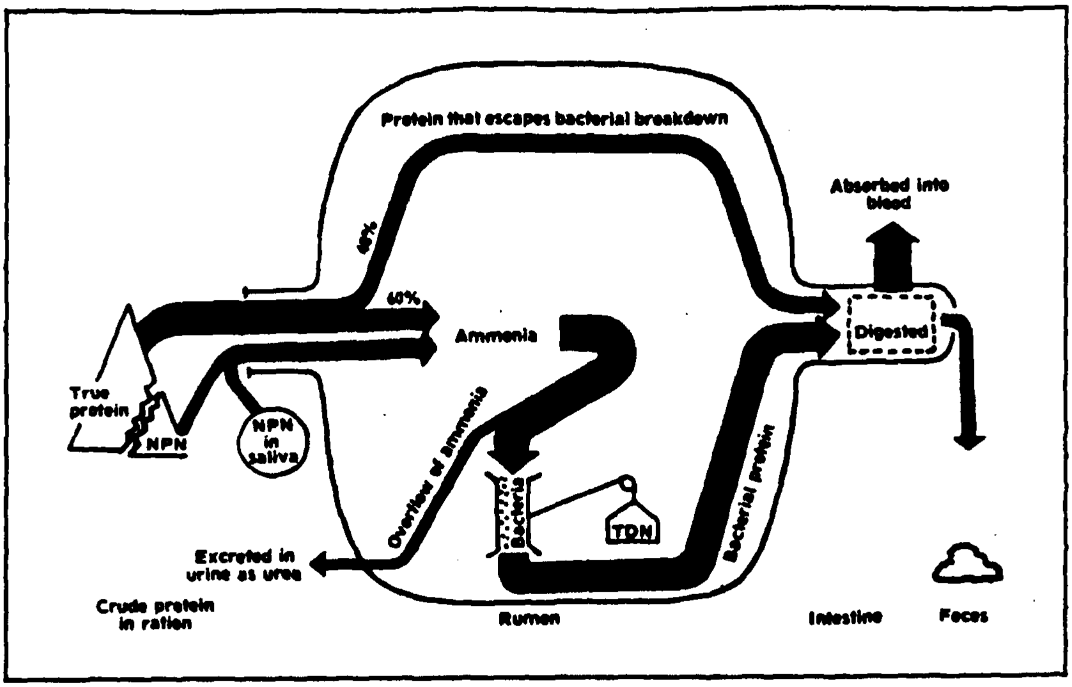


FIGURE 1. Schematic Summary of Protein Utilization in the Ruminant.

as mentioned earlier, as milk production increases, a substantial amount of additional dietary protein from protein supplements must escape rumen fermentation to meet the animal's requirements for protein. To emphasize this point, Muller et al. (1975) treated whey protein concentrate with formaldehyde (to increase the bypass protein content) and compare to an untreated form. Milk yield (64.6 vs 60.8 lb) and fat percent (3.42 vs 3.10) were improved by the treatment. Whey proteins are some of the highest quality proteins provided by nature. Because high producing ruminants require more undegraded dietary protein, it is important to identify good sources of bypass protein feedstuffs that are more resistant to microbial degradation in the rumen. Such information is helpful for formulating rations to meet the animals' needs for undegraded intake protein.

Animal protein by-product feedstuffs such as meat and bone meal, blood meal, feather meal, and fish meal are high in protein content as well as being good sources of undegradable or bypass protein. The key to using such products in animal diets, depends on cost and availability, quality and consistency of product, impact on animal performance and palatability.

## Animal By-products

Animal by-products that are available as protein supplements are products of the rendering and meat packing industries. Since they are processed in different locations and at different times and frequently with variable temperatures and pressures, they can be expected to vary some in quality and nutritive value.

Animal by-products that are presently being used some in ruminant diets as protein supplements are blood meal, fish meal, meat and bone meal, meat meal and hydrolyzed feather meal. They have been defined in the 1989 Feed Industry Red Book:

Blood meal: Raw dried blood is made from clean animal blood exclusive of urine, hair, and stomach contents. It contains approximately 87% crude protein (DM) of which 20% is degraded in the rumen. Flash drying is a newer process which produces a uniform product in color with a lysine content of about 9% (80 to 90% available). Biological availability of protein in blood meal is 80%.

Fish meal: Made from clean, dried, ground, and undecomposed fish. It is rich in essential amino acids. It contains about 67% crude protein (DM) of which 40% is degraded in the rumen. The variability of fish meal in degradability is dependent on the variation in processing conditions.

Hydrolyzed feather meal (HFM): The product resulting from the treatment under pressure of clean, undecomposed feathers from slaughtered poultry, free of additives, and/or accelerants. Feather meal contains about 85% crude protein (DM) of which 30% is degraded in the rumen. Although feather meal has a relatively poor balance of amino acids particularly lysine and methionine, it is a good source of sulfur due to its high cystine content. It should not contain less than 75% digestible crude protein as measured with pepsin-HCl.

Meat and bone meal (MBM): The rendered product from mammal tissues, including bone, which contains about 54% crude protein (DM) of which 50% is degraded in the rumen. It contains a minimum of 4 % phosphorus with the calcium level not more than 2.2 times the actual phosphorus level.

Meat meal: Defined the same as MBM except that no minimum phosphorus level is required.

Table 1. Composition of animal protein feedstuffs as compared to plant protein supplements high in escape protein (as fed).

| Feedstuff | DM | CP | BP | TDN | Ca | Phos |
|---|---|---|---|---|---|---|
| | % | | | | | |
| Animal protein | | | | | | |
| Blood meal | 92 | 80 | 82 | 61 | 0.29 | 0.24 |
| Fish meal | 90 | 60 | 65 | 63 | 5.30 | 3.10 |
| Feather meal | 90 | 80 | 70 | 63 | 0.20 | 0.72 |
| Meat and Bone meal | 92 | 50 | 63 | 66 | 10.00 | 5.10 |
| Meat meal | 94 | 51 | 63 | 67 | 8.80 | 4.40 |
| Plant protein | | | | | | |
| Brewers' grains | 90 | 25 | 54 | 62 | 0.30 | 0.48 |
| Corn gluten meal | 90 | 60 | 55 | 81 | 0.02 | 0.62 |
| Distillers, corn | 90 | 27 | 52 | 78 | 0.09 | 0.36 |

## Impact of Animal Proteins on Milk Yield

While a number of studies have been conducted using animal protein by-products as sources of bypass protein, additional work is needed to clarify recommendations regarding their impact on performance. Davison et al. (1982) used cows in mid-lactation to determine responses in milk yield and composition when grazing pastures and receiving corn silage supplemented with and without meat and bone meal (MBM). Milk yields (lb/d) and milk fat (%) were different at 34.7, 32.5 and 3.61, 3.30 with and without MBM. Craig and Broderick (1983) using high dry matter alfalfa haylage and corn silage rations reported no advantage of adding meat meal when compared to 15% protein (DM) diets containing urea and soybean meal. The results are given in Table 2.

Table 2. A comparison of added meat meal with other protein supplements on dry matter intake, milk yield and composition.

| Diets | DMI (lb) | MY (lb) | Fat (%) | Protein (%) |
|---|---|---|---|---|
| Urea | 55.9 | 72.4 | 3.53 | 3.19 |
| Soybean meal (SBM) | 55.7 | 71.7 | 3.40 | 3.25 |
| Meat meal (MM) | 54.3 | 73.5 | 3.41 | 3.11 |
| SBM plus MM | 54.8 | 72.4 | 3.53 | 3.22 |

Craig and Broderick JDS (Suppl.)66:345.

Kellems et al. (1989) studied the effect of replacing 50% and 100% of the supplemental crude protein provided by meat and bone meal with feather meal. Rations were formulated to be isonitrogenous and isocaloric. Feed intake was not different ($P < .05$) between groups during the trial. Results are in Table 3.

Table 3. Effect of Replacing 50% and 100% of the Supplemental Crude Protein by Meat and Bone Meal with Feather Meal on Production Performance.

| Diet | FCM (lb) | Fat (%) | Protein (%) |
|---|---|---|---|
| Meat and Bone meal[1] | 82.7 | 3.32 | 2.90 |
| Feather meal (50%) | 80.5 | 3.33 | 3.00 |
| Feather meal (100%) | 78.5 | 3.36 | 2.91 |

[1]MBM provided 45% of the crude protein in the supplement.
Kellens et al. J. Anim. Sci. (Suppl. 1)67:531.

The researchers suggested that feather meal could be used as a viable supplemental protein source for lactating dairy cows in spite of the 2 lb decrease in milk yield with each increment increases in feather meal.

Harris, et al. (1991) used 36 early to mid-lactation Holstein cows to determine the effect of three levels of hydrolyzed feather meal (0, 3 and 6% of DM) and two levels of protein (14 and 18%) in total mixed rations (corn silage 50% of DM) on feed intake, milk yield and milk composition. The results are in Table 4.

Table 4. Least square means for main effects of protein and feather meal levels on dry matter intake, milk yield, fat percent, and protein percent.

| Protein | FM | DMI | MY[1,2] | Fat | Protein[3,4] |
|---|---|---|---|---|---|
| (%) | (%) | (lb) | (lb) | (%) | (%) |
| Average of 14 and 18% protein | 0 | 49.3 | 55.8 | 3.46 | 3.17 |
| | 3 | 49.7 | 59.7 | 3.32 | 3.11 |
| | 6 | 49.6 | 55.8 | 3.42 | 2.95 |
| | Interaction of Protein and Feather Meal | | | | |
| 14 | 0 | 49.7 | 53.9 | 3.40 | 3.11 |
| | 3 | 49.4 | 62.2 | 3.36 | 3.03 |
| | 6 | 49.0 | 54.6 | 3.48 | 2.89 |
| 18 | 0 | 48.9 | 57.7 | 3.54 | 3.23 |
| | 3 | 50.1 | 57.2 | 3.28 | 3.19 |
| | 6 | 50.1 | 57.0 | 3.37 | 3.01 |

[1]Curvilinear effect of feather meal P = .027
[2]Interaction of curvilinear effect of feather meal with crude protein P = .023
[3]Linear effect of feather meal on milk protein percent P=.0001.
[4]Effect of ration protein level on milk protein percent P=.001.

Table 5. Performance of cows in early Lactating Fed Isonitrogenous Diets Containing SBM or Animal By-Product Meals.[1]

| | Diet | | | |
|---|---|---|---|---|
| | SBM | FM | A | B |
| Ration, % DM | | | | |
| Fish meal | | 7.4 | | |
| SBM | 15.4 | 6.7 | 6.7 | 6.7 |
| DMI, lb/d | 35.0 | 32.3 | 36.1 | 35.4 |
| MY, lb/d (51-100 d) | 60.5 | 61.8 | 63.1 | 62.5 |
| Fat, % | 3.54[a] | 3.07[b] | 3.36[a] | 3.49[a] |
| Protein, % | 3.15[a] | 3.13[a] | 2.97[b] | 3.05[a,b] |
| FCM | 56.3[a] | 52.6[b] | 57.2[a] | 58.3[a] |

[a]Ration A = blends of meat and bone, meat, blood and feather meal.
Ration B = same as above but more blood and less fish.
[a,b]Means in the same column with different superscripts differ (P < .05).
Mantysaari et al. JDS 72:2958.

The three levels of feather meal used in the study had no effect on dry matter intake or palatability. There was a positive curvilinear effect of feather meal (P < .027) on milk yield with the effect being exhibited at 14% dietary protein but not at 18%. The linear decrease in milk protein percent with increasing levels of feather meal suggests a possible shortage of amino acids available in the small intestine for maximizing protein synthesis. Waltz et al. (1989) reported that total tract nitrogen digestibility was lower for diets containing feather meal (63.4%) and blood meal-feather meal combinations (66.3%) than for soybean meal (73.9%).

Mantysaari et al. (1989) used 80 primiparous cows to measure the performance of early lactating cows fed diets containing soybean meal and animal by-product meals. The commercial by-product meals contained a blend of meat and bone, meat, poultry, blood and feather meals. All diets contained corn silage (54.8% DM), corn, wheat midds and soybean meal. The results are in Table 5.

Increased supply of protein from animal by-product meals did not increase milk yields of first-lactation cows. Inclusion of menhaden fish meal in the ration at a rate of 7.4% of total DM decreased fat percent and dry matter intake.

DeGracia et al (1989) used 12 midlactation Holstein cows to compare a corn gluten meal and blood meal mixture with soybean meal as supplemental protein sources. Al experimental diets contained 60% ammoniated corn silage (DM) and corn and oats (2:1) as the basal concentrate mixture. The results of the study are in Table 6.

Table 6. Dry Matter Intake, Milk Yield and Composition.

| | | Corn gluten and blood meal | | |
|---|---|---|---|---|
| | Control | Low (LM) | High (HM) | SBM |
| Ration, % DM | | | | |
| Crude Protein | 12.46 | 14.33 | 16.85 | 16.14 |
| Urea | .20 | -- | -- | -- |
| CGM | -- | 2.04 | 3.59 | -- |
| Blood meal | -- | 1.50 | 2.61 | -- |
| SBM | -- | -- | -- | 10.80 |
| DMI, lb/d[a] | 42.5 | 43.8 | 44.4 | 46.2 |
| MY, lb/d[b] | 52.8 | 53.9 | 56.5 | 54.6 |
| Fat, %[c] | 3.83 | 3.74 | 3.58 | 3.67 |
| Protein, %[a] | 3.31 | 3.39 | 3.40 | 3.40 |

LM = Low protein mixture; HM = High protein mixture.
[a]C vs. LM, HM, and SBM ($P < .05$).
[b]C vs. LM, HM, and SBM ($P < .10$).
[c]C vs. LM, HM, and SBM ($P < .01$), LM vs. HM and SBM ($P < .05$).
DeGracia et al. JDS 72:3064.

Milk yields were slightly, but not significantly lower for cows fed the control diet than for cows fed other diets. Milk yields did not differ (P < .10) between cows fed the low and high concentrations of protein or between the low degradable (HM) and high degradable (SBM) sources, indicating that protein intake was adequate.

A number of studies have been conducted in recent years regarding the utilization of fish meal as a protein supplement for high producing dairy cows. In 1982, Miller et al. (1982) used 12 commercial dairies to study the effect of replacing 1.65 lbs of barley or sugar beet pulp with fish meal. The response to fish meal in the first month of the experiment was about 5.9 lbs more milk/day with an average increase over a 4-month period of 2.8 lbs/day. A number of other studies are in Table 7. reduction in milk fat percentage with fish meal supplementation has been detected by several investigators (Blauwiekel et al., 1989; Spain et al., 1989). It has been suggested that the high levels of free fatty acids found in some fish meals reduces milk fat percent by reducing the acetate:propionate ratio or altering the lipid metabolism post-ruminally.

Table 7. Influence of animal protein by-products on dry matter intake and milk yield and composition.

| Reference | Protein Suppl. | DMI lb/day | MY lb/day | Fat % | Protein % |
|---|---|---|---|---|---|
| 1. Arizona King et al. | Blood meal | 33.0 | 44.4 | 3.75[a] | 2.90[a,b] |
| | CGM[1] | 36.1 | 44.7 | 3.75[a] | 3.06[a] |
| | CSM | 37.4 | 52.8 | 3.38[b] | 2.78[b] |
| 2. West Virginia (Hol.) Blauwiekel et al. | Fish meal | 42.0 | 82.1 | 3.02 | 2.97 |
| | CGM | 39.4 | 75.0 | 3.79 | 2.76 |
| 3. Virginia Tech (Expt. 2) Spain et al. | SBM[1] | 31.2 | 59.0 | 2.89 | 3.20 |
| | Fish meal | 31.9 | 59.6 | 2.11 | 3.04 |
| | CGM | 27.3 | 54.1 | 3.13 | 2.95 |
| | CGM:SBM | 32.1 | 59.4 | 2.82 | 2.99 |
| | FM:SBM | 31.7 | 60.9 | 2.37 | 3.01 |
| 4. Tennessee (Multiparous) Bernard, J. K. | SBM | 50.4[a] | 61.2[a] | 3.57[a] | 3.10 |
| | CSM | 54.8[b] | 60.9[a] | 3.61[a] | 3.05 |
| | MBM | 54.1[b] | 63.8[b] | 3.35[b] | 3.02 |
| 5. Rutgers Univ. Chmiel, S. L. | SBM | -- | 80.7 | 3.20 | 3.10 |
| | Fish meal | -- | 84.9 | 2.50 | 2.90 |
| | CGM | -- | 74.1 | 3.20 | 3.00 |

[1]MBM = meat and bone meal, CGM = corn gluten meal
[a,b]Means in same row with superscripts differ ($P<.05$).

## Summary

Feeding animal protein by-products to high producing dairy cows has been done successfully in some dairy herds. Such products should be blended with the grain and forage component of the ration to help alleviate any palatability problems. The addition of molasses to the ration may be beneficial, especially when the protein by-product is added to the concentrate. The inclusion rate of meat and bone meal should be limited to about 2 lb/cow/day since feeding this amount adds a good amount of calcium and phosphorus to the ration. Hydrolyzed feather meal and fish meal should be added gradually to prevent depression of feed intake. Inclusion rates in a TMR (DM) is generally less than 4 to 5 percent. Blood meal has been used successfully in rations at about 0.5 to 0.75 lb/cow/day. A mixture of the animal protein by-products are used by a number of commercial vendors in order to arrive at a more desirable amino acid balance.

Rations formulated for high producing cows in early lactation should contain about 18% crude protein with 35-38% escape protein. Since animal protein by-products are low in degradable intake protein, caution must be observed to not underfeed degradable intake protein.

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