# MODEL PREDICTIONS OF RUMEN UNDEGRADED PROTEIN (RUP) DIGESTIBILITY AND QUALITY OF RUP SOURCES

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## INTRODUTCION

The more sophisticated ruminant nutrition models have progressed to metabolizable protein (MP) systems, which allow users to balance diets for amino acids (AA). In order to accurately predict AA supplied from RUP, digestibility coefficients for the RUP fraction of feeds are considered by the models. Therefore, the objectives of this paper are to describe RUP digestibility coefficients in the NRC (National Research Council, 2001) and CNCPS v.6.1 models, to discuss the effects of RUP quality on intestinal digestibility, and to describe the updates in the CPM feed dictionary pertaining to blood meal digestibility. These objectives will be discussed in two sections.

## MODEL PREDICTIONS OF RUP DIGESTIBILITY

## SUMMARY

- The current dairy NRC (2001) and CNCPS v.6.1 models recognize differences in post-ruminal digestibility of RUP among feed ingredients.

- These models assume digestibility of individual AA in RUP is the same as digestibility of total RUP, but digestibility of individual AA in the RUP fraction (RUP-AA) of feedstuffs does vary, particularly lysine digestibility.

## INTRODUCTION

The current poultry and swine NRC models (National Research Council, NRC 1994; NRC, 1998, respectively) allow users to formulate diets based on digestible amino acid (AA) supply. This is possible because the models recognize that small intestinal digestibility of individual AA is not necessarily the same as small intestinal digestibility of total crude protein (CP) in feed ingredients. Therefore, digestibility coefficients are assigned to individual AA in each feed ingredient within the poultry and swine NRC models. In ruminant nutrition models, differences in RUP digestibility among feeds are recognized (Sniffen et al., 1992; NRC, 2001; Tylutki et al., 2008), but currently these models assume that digestibility of RUP-AA is the same as digestibility of total RUP.
Cornell Net Carbohydrate and Protein System (CNCPS)

The CNCPS v.6.1 model uses a chemical fractionation method to describe the characteristics of protein in feeds (Sniffen et al., 1992; Tylutki et al., 2008). The model divides feed protein into 5 fractions: A, B1, B2, B3, and C. The amount of protein in each fraction that escapes ruminal degradation is calculated by the model based on relative rates of degradation and rates of passage. For the protein that escapes ruminal degradation, the model assigns post-ruminal digestibility coefficients specific to each of the protein fractions. Digestibility coefficients of 100%, 100%, 80%, and 0% are assigned to the undegraded B1, B2, B3, and C protein fractions, respectively. Therefore, the model does not assign RUP digestibility coefficients to individual feedstuffs, but feed differences in RUP digestibility are indirectly accounted for based on differences in the proportions of B1, B2, B3, and C in feed protein. For example, fraction C is considered to be completely undegradable in the rumen and completely indigestible in the intestinal tract; therefore, if feeds contain higher proportions of fraction C, the intestinal absorption of dietary protein will be predicted by the model to be lower than if feeds contain greater proportions of the other fractions.

NRC (2001)

The current dairy NRC (2001) model employs a different approach for estimating RUP digestibility. In NRC (2001), ruminal degradation characteristics of individual feeds were determined based on literature reported estimates of *in situ* determined rates of ruminal protein degradation. The model then calculates the contribution of each feed in the diet to total dietary rumen degradable protein (RDP) and RUP based on rates of degradation and rate of passage. Digestibility of RUP is then calculated using RUP digestibility coefficients assigned to each feed ingredient that contributes to RUP. The RUP digestibility coefficients were determined based on a summary of 54 studies that reported RUP digestibility for individual feed ingredients. The mobile bag technique (MBT) was used in 48 of the studies and the three-step procedure (TSP) of Calsamiglia and Stern (1995) was used in 6 studies. The mean RUP digestibility values reported for each feed were calculated and rounded to the nearest 5 percentage units to emphasize the lack of precision in arriving at mean values. The RUP digestibility coefficients in the NRC (2001) feed library range from 50% for cottonseed hulls and canola seeds to 95% for skim milk powder.

The CNCPS v.6.1 and NRC (2001) models both account for differences in RUP digestibility among feeds, which represents a significant advancement in ruminant nutrition models. However, it is also important to note that RUP digestibility coefficients are not static within a feed type. For example, as stated, the RUP digestibility coefficients in the NRC (2001) model are the average of literature reported values. However, the standard deviation of the mean (SD) for some feedstuffs was quite large when the data was summarized (C. G. Schwab, personal communication). For example, the SD for RUP digestibility of grass silage was 22.5, and the SD for the RUP digestibility of canola meal was 10.6. Therefore, if nutritionists rely on model default values for RUP digestibility, metabolizable protein (MP) supply can be over or underestimated by the model.

In addition, the above models do not recognize differences in RUP-AA digestibility within feeds, which is likely due to limited availability of data. However, differences in RUP-AA digestibility within feeds have been reported (Prestløkken and Rise, 2003). Therefore, the development of nutritional models that account for differences in RUP-AA digestibility within feeds will allow industry professionals to more precisely match AA supply to AA requirements. This will allow for maximal efficiency of use of dietary AA for milk protein synthesis, which can improve herd profitability and decrease nitrogen excretion.

## QUALITY OF RUP SOURCES

### SUMMARY


- Heat treatment of feedstuffs can impact feed quality, particularly quality of RUP.
- Of all AA in feed protein, lysine is generally the most susceptible to damage during heat processing.
- Recognizing variability in RUP quality, particularly quality of blood meal, can aid in improved ration formulation to meet MP and MP-lysine requirements.
- The updated CPM feed dictionary contains 2 blood meal entries to reflect variation in RUP digestibility of blood meal.


### INTRODUCTION

Heat treatment of feedstuffs is utilized to decrease ruminal degradation of feed protein and increase the proportion of RUP. Heat application for this process needs to be carefully controlled because excess heat can destroy lysine and depress intestinal lysine digestibility (Faldet et al., 1992; Pereira et al., 1998). Monitoring the effect of heat treatment on intestinal digestibility of lysine in RUP (RUP-lysine) is especially important for lactating cows because lysine is often co-limiting with methionine or second limiting for milk and milk protein production in North America where diets high in corn products are fed (NRC, 2001). When feeds are heated to decrease the proportion of RDP and increase the proportion of RUP, the greatest benefit will be observed if the RUP is readily digested and RUP-AA are readily absorbed by the animal. Processing methods that increase RUP supply without damaging RUP-lysine should be used.

Monitoring lysine and protein damage during the drying process of wet feeds is also important. The amount of distillers dried grains with solubles (DDGS) fed to ruminants is increasing, and the vast majority of DDGS fed in the U.S. is the resultant by-product of the production of fuel ethanol from corn. The AA profile of corn is not desirable for ruminants, as corn protein has a low content of lysine (2.84% of CP; NRC, 2001). However, standard corn meal is low in protein (9.4% CP; NRC, 2001) and most of that protein is degraded in the rumen and incorporated into microbial protein, which has an improved AA profile. Distillers dried grains with solubles has a higher CP concentration than corn (29.7%; NRC, 2001), and more of the protein in DDGS remains undegraded in the rumen and arrives at the small intestine intact (NRC, 2001). This can negatively impact the AA profile of MP if other feedstuffs that are high in RUP-lysine are not included in the diet. These effects are further confounded by the fact that RUP digestibility of DDGS is lower than corn meal, and RUP-lysine digestibility for DDGS is lower than the digestibility of the other AA (Boucher et al., 2009). Therefore, the inferior AA profile of MP that results when feeding DDGS can be further exacerbated by the decrease in digestibility of RUP and RUP-lysine. Decreases in milk protein concentrations have been reported when DDGS replaced corn meal and soybean meal in the diet of lactating cows (Kleinschmit et al., 2006) and when DDGS replaced wet distillers' grains with solubles (Anderson et al., 2006). Therefore, assessing lysine damage due to the drying process of distillers grains is critical to the successful feeding of DDGS to lactating dairy cows.

Monitoring lysine damage during the drying of blood meal is also critical. Blood meal obviously needs to go through a drying process before it is fed to cattle. The lysine concentration of blood meal is about 9% of CP (NRC, 2001), which makes blood meal a desirable feed ingredient to increase lysine concentrations in MP (MP-lysine). However, if the lysine is damaged in the processing of blood meal, MP-lysine supply will be overestimated by current ruminant nutrition models.

## CPM FEED DICTIONARY UPDATE – BLOOD MEAL

Due to the variation of protein and lysine digestibility in blood meal, the updated CPM (Cornell, Penn, Miner) feed dictionary contains two blood meal entries. Literature reported data as well as feed analysis methods were discussed at length between Dr. Charlie Sniffen, Kurt Cotanch, and the author to develop these two entries. The entry labeled "Bloodmeal 90%Dig CPM Orig," is the original blood meal entry that was available in the previous versions of the CPM dictionary. However, in order to provide nutritionists with a tool to help in ration formulation with a blood meal of lesser quality, "Bloodmeal 65%Dig" was added to the dictionary.

The proportion of CP allotted to the various CPM protein fractions for the two blood meal entries are listed in Table 1.

Table 1. Protein fractions of blood meal in CPM feed dictionary update

| Protein Fraction, % of CP | Bloodmeal 65%Dig | Bloodmeal 90%Dig. CPM Orig. |
|---|---|---|
| A | 3.660 | 3.44 |
| B1 | 0.00 | 0.217 |
| B2 | 69.340 | 51.847 |
| B3 | 0.00 | 36.819 |
| C | 27.00 | 0.930 |

The rationale for the modeling approach for the “Bloodmeal 65%Dig” entry was that for animal protein sources, there is a proportion of the protein that is undegradable and indigestible in the ruminant animal (Boucher, 2008). This portion of the protein should be reflected in the C fraction, because in CPM, the C fraction is completely unavailable to the animal. There is also some protein in blood meal that is rapidly solubilized and utilized by the rumen microbes, which is reflected in the A fraction. The remaining protein in blood meal will be degraded at a slow rate in the rumen, and the rate of degradation of protein in any one of the B fractions should be similar. Therefore, the remaining portion of blood meal protein was modeled in the B2 fraction. We believe this more accurately reflects the digestion kinetics of blood meal in the ruminant.

Analysis of digestibility or availability of AA in blood meal at a commercial laboratory is not currently available on a routine basis. Therefore, deciding which blood meal value to use in ration formulation may need to be based on experience rather than hard and fast data, at least for now. Some considerations that may be helpful in deciding which blood meal entry to use are below:

- Do not judge a book by its cover, i.e., the color or appearance of blood meal is not a good indicator of its quality

- Track when a new load of blood meal is fed to the herd. Are there any changes in production or components?

- If possible, identify and utilize a consistent source of blood meal.
- Add rumen protected lysine to the ration and observe if the herd responds to the additional lysine. This may indicate that the lysine content and/or availability in the blood meal is compromised.

## CONCLUSIONS

Ruminant nutrition models recognize differences in RUP digestibility among feedstuffs. However, the models do not account for variation in digestibility of AA in feed ingredients. Therefore, AA content in MP can be over-or under-estimated in these models. Heat processing of feeds can decrease intestinal digestibility of feed protein and can compromise lysine availability from the feed. Recognizing variation in RUP quality is particularly important for blood meal because of its high RUP and RUP-lysine content. Providing various entries into ration formulation libraries will allow nutritionists to more appropriately formulate rations according to the quality of RUP sources that they utilize. In order to move this effort forward, two entries for blood meal in the CPM feed dictionary update have been provided.

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