

Determination of Ruminant Protein Degradation Kinetics of Soy Best with and without Soy Gums to be used in the CPM-Dairy Nutrition Model

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Disclosure and liability. The information in this report supersedes any previous data analysis, results and discussions, conclusions, and recommendations of the experiment and/or product described herein.

Executive Summary

A dynamics model was built to determine fractional degradation rates (kd) of Soy Best products (with and without soy gums) based on ruminal in situ disappearance of protein data. The simulated kd (available protein, fraction B) for Soy Best with and without soy gums were 1.66 and 3.16 %/h, respectively. Furthermore, model simulations of ruminal fermentation and escape kinetics suggested that rumen-undegradable protein of Soy Best with soy gums applied according to the conditions specified in the patent #7297356 is likely to be 78.3 and 63.1% for fresh- and mid- to late-lactating cows.

In light of limited data, the manufacturer of Soy Best recommends using a fractional rate of degradation of PROT B2 of 2 %/h until further studies are conducted.

Objectives

The objective of this experiment was to determine the degradation kinetics in the rumen of Soy Best protein with and without soy gums based on research data of in situ digestibility of protein.

Material and Methods

Determination of the ruminal degradation kinetics of protein. A dynamic model (Figure 1) was built to simulate the available data on RUP of Soy Best with and without soy gums. This model contains three differential equations (dCP_c/dt , dCP_b/dt , and CP_a/dt) and passage and degradation fractional rates for each pool.

Simulation of Rumen-Undegradable Protein. The dynamic model (Figure 1) and chemical composition of different soybean meal (SBM) products were used to predict RUP under two different scenarios: fresh-lactating cows (assuming $k_p = 8\%/h$) and mid- to late-lactating and dry cows ($k_p = 4\%/h$).

Simulation of milk production and feasibility of application of Soy Best products. All simulations were performed with the CPM-Dairy 3.0.8.

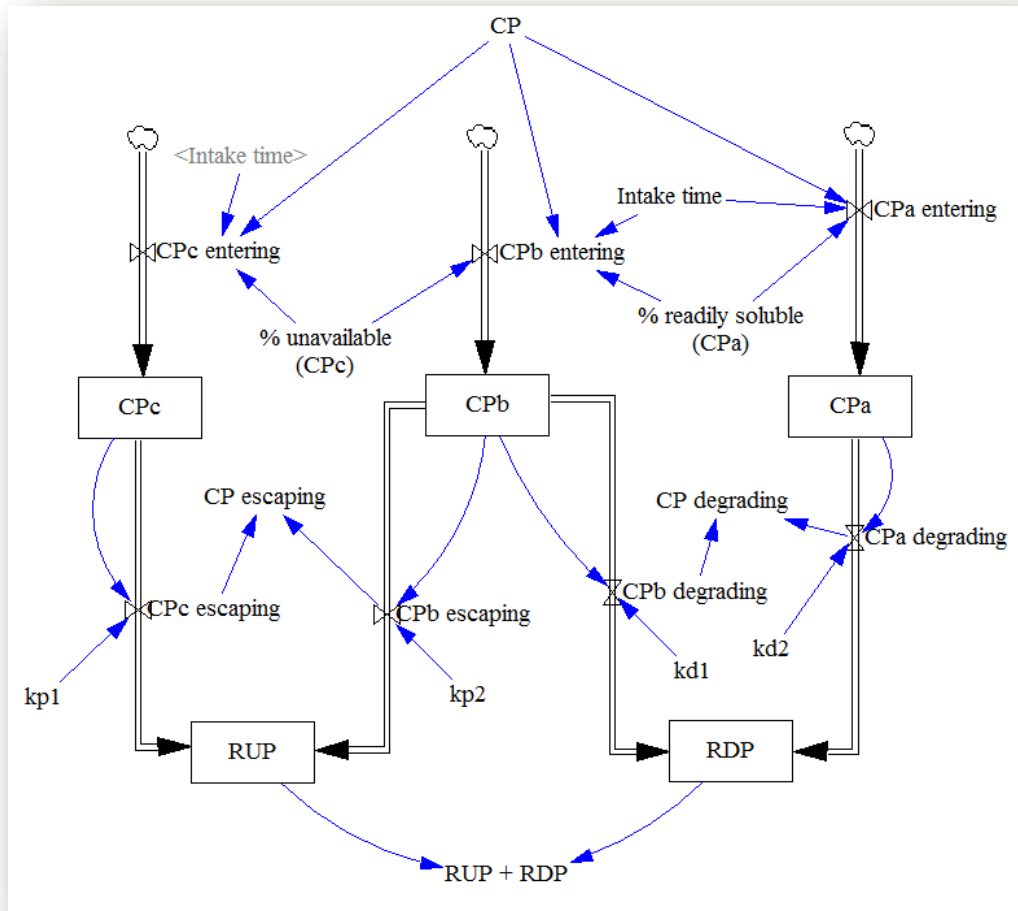


Figure 1. Schematic representation of a three-compartment dynamic model to simulate the ruminal degradation kinetics of a three-fraction protein system. Acronyms CPa, CPb, and CPc represent the readily/instantaneous available, intermediate available, and unavailable protein fractions, respectively; kp is fractional passage rate, 1/h; and kd is fractional degradation rate, 1/h. All simulations were performed using Vensim Pro 5.6a.

Results and Discussions

Determination of the Ruminal Degradation Kinetics of Protein

In situ protein degradation. The data from Awawdeh et al. (2007) was used to calibrate the model shown in Figure 1. Appendix 1A has the graphic representation of RUP for lignosulfonate-treated SBM (LSBM) and expelled SBM (ESBM). For these simulations, kp was assumed to be 8 %/h, and the CPc, CPa, and kd were assumed to be as reported in the manuscript. Our model computed RUP at 48 h of simulation of 79.5 and 57.2% for LSBM and ESBM, respectively. The observed values were 81 and 56%,

respectively (Awawdeh et al., 2007). The k_d was determined to be 2 and 2.6 %/h, respectively (Awawdeh et al., 2007).

Determining protein k_d for Soy Best products. The data from Stern et al. (2005) of in situ measurement of RUP of Soy Best with and without soy gums were used to determine the degradation kinetics of CPb (k_{d1} , Figure 1). Because the value reported was obtained with ruminal incubation of Dacron bags for 16 h, the feed particle is not able to escape the rumen; therefore, k_{p1} and k_{p2} (Figure 1) were set to zero and only k_{d1} was changed until the observed RUP matched the predicted RUP after 16 h of simulation. The unavailable (fraction C) and readily available (fraction A) were assumed to be 1.6 and 4.9% of CP based on the chemical composition of Soy Best products. These values are currently used in the CPM-Dairy model. A graphical representation of the dynamics of RUP is shown in Appendix 1B. The simulated fractional degradation rates for Soy Best with (MEC1G) and without (MEC1) soy gums were 1.66 and 3.16 %/h, respectively, in order to obtain 73.3 and 58% of RUP.

Simulation of Rumen-Undegradable Protein

Appendix 2 has the results of the prediction of RUP using the chemical composition and fractional degradation rates shown in Table 1.

Table 1. Physicochemical composition of soybean meal products used to simulate the rumen-undegradable protein ¹

Products	Readily available protein (CPa), % of CP	Unavailable Protein (Cpc), % of CP	Fractional degradation rate of CPb, %/h
AminoPlus	0.763	4.33	3.30
SoyPlus	7.151	2.43	3.35
SoyPass	4.501	4.09	2.12
Soy Best w/o soy gums	4.886	1.63	3.16
Soy Best with soy gums	4.886	1.63	1.66

¹ Physicochemical composition was obtained from the CPM-Dairy feed dictionary except for k_d for Soy Best products.

As shown in Table 1, Soy Best products have the least amount of unavailable protein (Cpc) and comparable values for readily available protein (CPa) to other SBM products. Even though the Cpc is part of the RUP, their availability might be lower than the CPb that escapes the rumen fermentation. Therefore, the availability of feed amino acids post-rumen might be affected (Stern, 2007). Therefore, the quality of the RUP of products that have lower values of Cpc might be greater than products that have more Cpc.

The model simulation of RUP after 48 h of simulation (Appendix 2) indicated that Soy Best with soy gums is likely to have RUP of 78.3 and 63.1% for fresh- and mid- to late-lactating cows. These values are similar to those observed by Stern et al. (2005). Soy Best with soy gums had the greatest value whereas SoyPlus had the least value for RUP (Appendix 2).

Further Analysis

The kd of CPb is a combination of three protein fractions in the CPM-Dairy 3.0.8 nutrition model. Below is the mathematical representation of the RUP in the CPM-Dairy 3.0.8 (LHS) compared to a single protein fraction (RHS) solved for kd (single protein fraction, similar to Figure 1).

$$PB1 * \frac{kp}{kp + kd1} + PB2 * \frac{kp}{kp + kd2} + PB3 * \frac{kp}{kp + kd3} = (PB1 + PB2 + PB3) * \frac{kp}{kp + kd}$$

$$kd \rightarrow \frac{(kd1 kd2 kd3 PB1 + kd1 kd2 kp PB1 + kd1 kd3 kp PB1 + kd1 kp^2 PB1 + kd1 kd2 kd3 PB2 + kd1 kd2 kp PB2 + kd2 kd3 kp PB2 + kd2 kp^2 PB2 + kd1 kd2 kd3 PB3 + kd1 kd3 kp PB3 + kd2 kd3 kp PB3 + kd3 kp^2 PB3) / (kd2 kd3 PB1 + kd2 kp PB1 + kd3 kp PB1 + kp^2 PB1 + kd1 kd3 PB2 + kd1 kp PB2 + kd3 kp PB2 + kp^2 PB2 + kd1 kd2 PB3 + kd1 kp PB3 + kd2 kp PB3 + kp^2 PB3)}{(kd3 + kp) ((kd2 + kp) PB1 + (kd1 + kp) PB2) + (kd1 + kp) (kd2 + kp) PB3}$$

Where kd is the overall fractional degradation rate for a single protein pool, kp is the fractional passage rate, PB1, PB2, PB3 are the protein fractions, and kd1, kd2, and kd3 are the fractional degradation rates for PB1, PB2, and PB3, respectively.

Assuming the value of kd is 1.66 %/h and the pool sizes of PB1, PB2, and PB3 are 4.194, 73.656, and 15.635 % of CP; respectively, one can compute the relationship between kd1, kd2, and kd3; respectively for PB1, PB2, PB3 fractional degradation rates. Appendix 3 shows a 3D plot with kp of 6%/h. Changes in the PB3 kd will have a greater impact on PB2 kd than changes in the PB1 kd (Appendix 3).

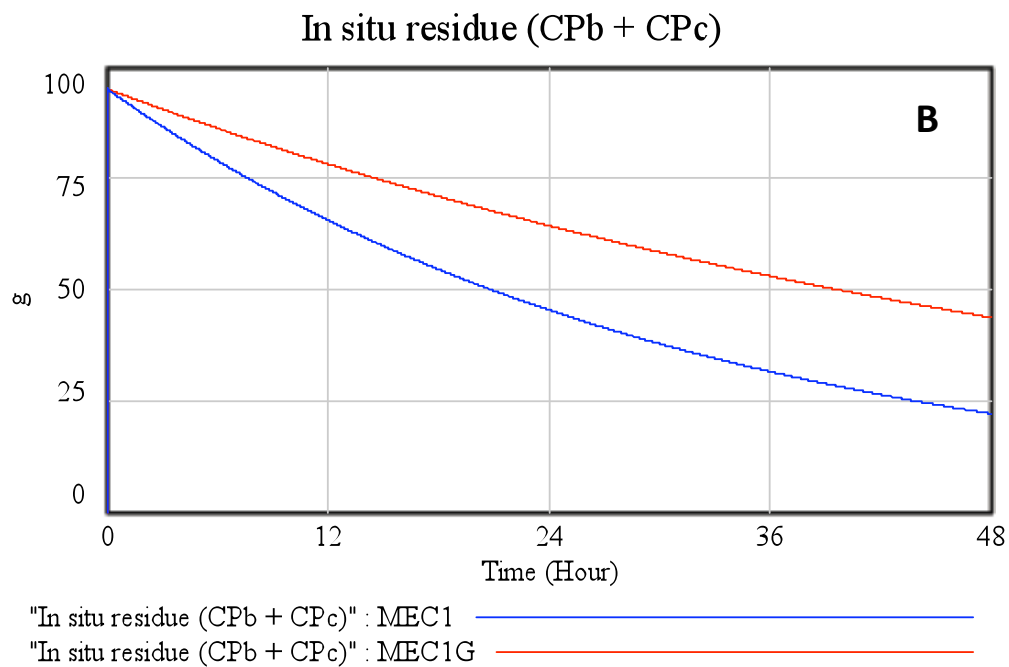
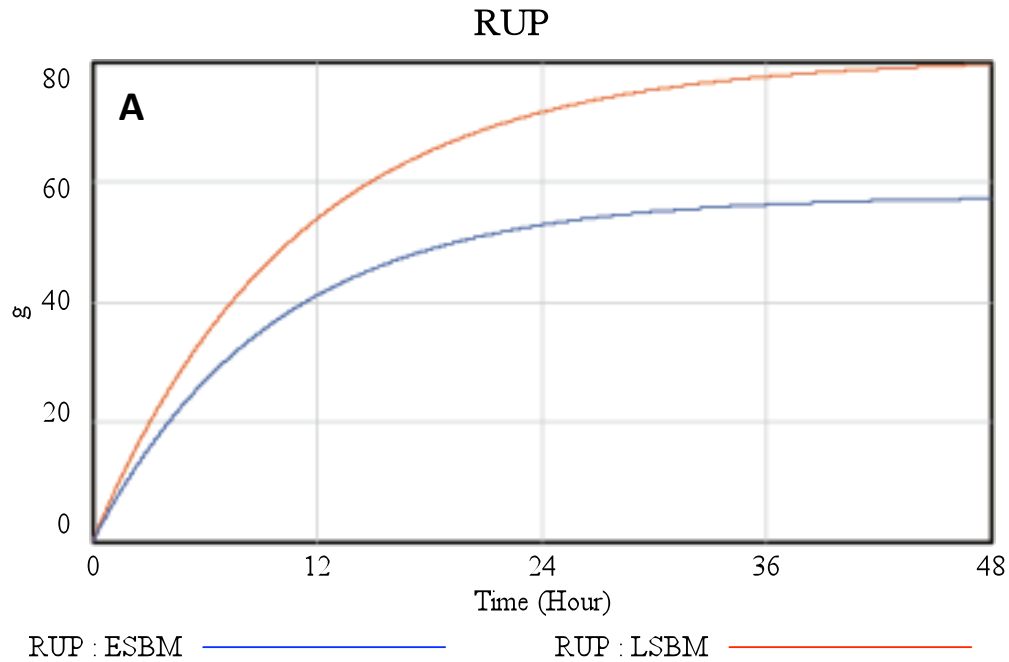
In fact, assuming kd1 of 145%/h and kd3 of 0.2%/h (CPM-Dairy 3.0.8 values), kd2 should be assigned to 1.62%/h to obtain the overall fractional rate of degradation of 1.66%/h. On the other hand, to obtain a PB2 kd of 2%/h, PB1 kd should be assigned to 3%/h (assuming PB3 kd does not change).

The kd of CPb of 1.66%/h (0.0166 h⁻¹) obtained in this analysis was based on one study that reported an in situ RUP value of 73.3% at 16 h of incubation. More experiments should be conducted to obtain accurate mean and variation of the CPb fraction kd of cows receiving typical Texas diets.

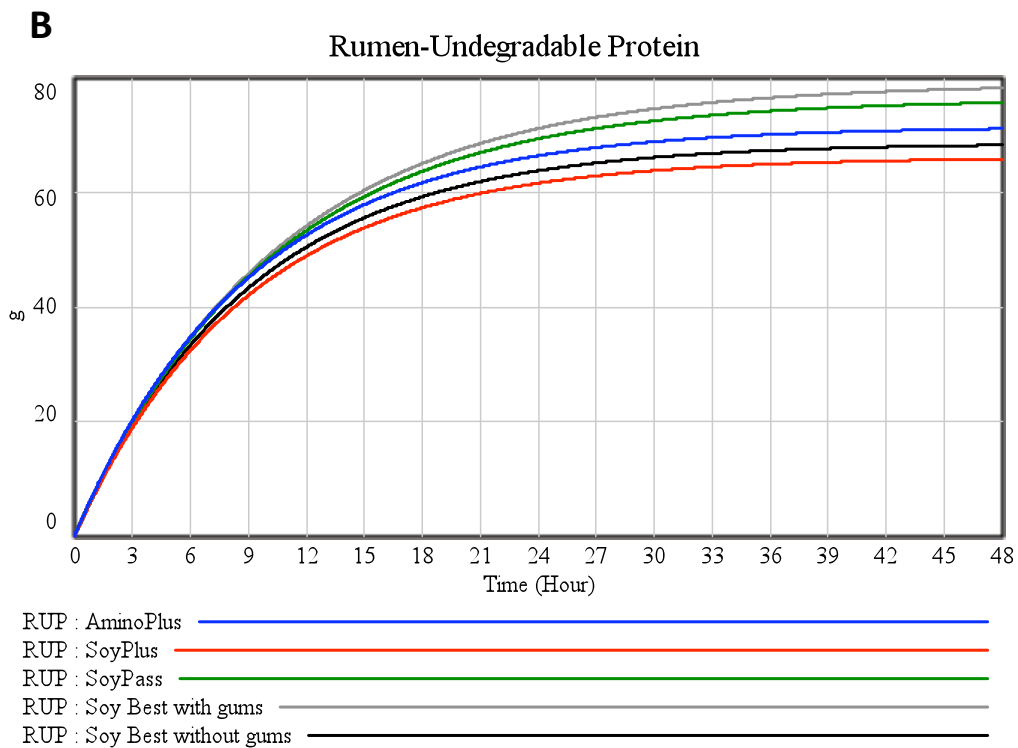
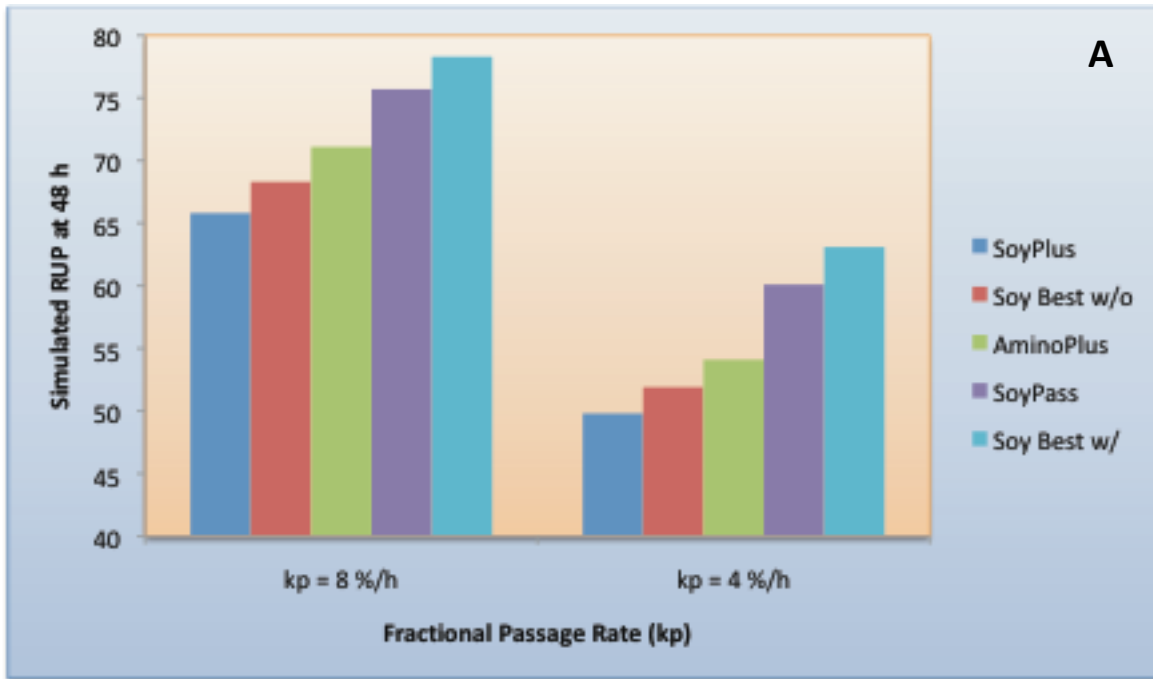
Literature Cited

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Appendix 1. Simulations of the dynamic model of ruminal protein degradation: (A) Rumen-undegradable protein (RUP) of lignosulfonate-treated SBM (LSBM) and expeller SBM (ESBM) using data from (Awawdeh et al., 2007) and (B) RUP of Soy Best with (MEC1G) and without (MEC1) soy gums (Stern et al., 2005).



Appendix 2. Simulated 48 h RUP using the dynamic model of ruminal protein degradation (A) assuming fractional passage rate (kp) of either 8 (fresh lactating cow) or 4 %/h (mid- to late-lactating cow) and (B) dynamics of RUP assuming kp = 8%/h for AminoPlus, SoyPlus, SoyPass, and Soy Best with or without soy gums.



Appendix 3. The relationship between fractional degradation rates of three protein fractions assuming an overall fractional degradation rate of 1.66%/h, passage rate of 6%/h, and the pool sizes of PB1, PB2, and PB3 as 4.194, 73.656, and 15.635 % of CP; respectively.

