Development of Protein Fractionation and Degradation Kinetics of Soy Best with Gums to be used in the NRC (2001) Nutrition Model

Luis Orlindo Tedeschi, PhD, PAS
Texas A&M University

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

Based on the characteristics of the CNCPS-based models (e.g. CPM-Dairy) and the NRC (2001) to compute rumen-degradable protein (RDP) and rumen-undegradable protein (RUP), an equation was developed to compute protein degradation kinetics equivalency between these models for the Soy Best with Gums product. The physicochemical composition described by the CPM-Dairy was used. Based on the developed equivalency equation these are the recommendations for Soy Best with Gums information for the NRC (2001): Prot A = 8.7 % CP, Prot B = 89.671 % CP, and Prot C = 1.629 %CP. The Prot B kd was estimated to be 1.64 %/h. These values should yield comparable RDP values between these nutrition systems.

Objectives

The objective of this study was to determine equivalency of protein fractionation and degradation kinetics between the CPM-Dairy and the NRC (2001) models for Soy Best with Gums product.

Material and Methods

Description of the Models

The CPM-Dairy/CNCPS models. In the CNCPS-based models, protein is divided into five fractions: A, B1, B2, B3, and C. The fraction A is the percentage of CP that is instantaneously solubilized and utilized by the microbial bacteria; it has a kd of 10,000 %/h. The fraction C is chemically determined as the CP bound to the acid detergent fiber; it has a kd of 0 %/h. The fraction B1, B2, and B3 are potentially degradable true protein with decreasing rates of degradation. Figure 1 depicts the protein fractionation. This fractionation was based on the work of Sniffen et al. (1992). Further discussion about the protein fractionation was provided by Lanzas et al. (2007).

The NRC (2001) model. The NRC (2001) adopted the in situ method to partition feed N fractions into rumen-degradable protein (**RDP**) and rumen-undegradable protein (**RUP**). Page 59 of the NRC

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(2001) describes the fractionation currently adopted. The in situ A fraction includes NPN, solubilized protein, and protein in particles smaller than the porosity of the nylon bag. The in situ B fraction is potentially degradable in the rumen, depending on the competition between digestion and passage fractional rates, and the in situ C fraction is the unavailable protein, which is estimated as the remaining nitrogen at the end of a predetermined incubation time.

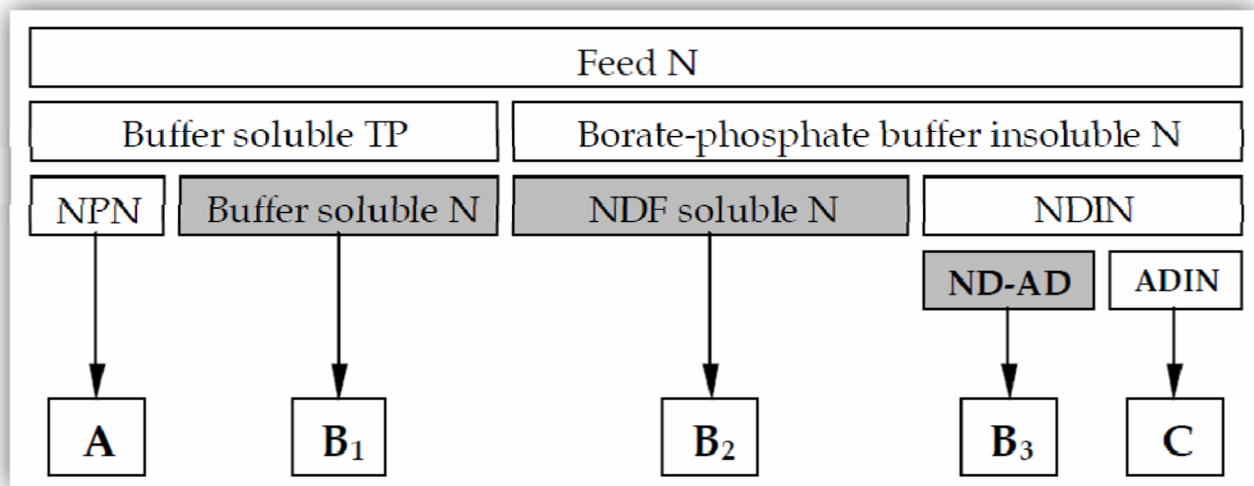

Figure 1. Partition of protein fractions of feeds on the CNCPS-based nutrition models.

Therefore, the NRC (2001) Prot A includes the CNCPS Prot A and might include some or all of the CNCPS Prot B1. The NRC (2001) Prot C is determined by in situ data to be the undegraded protein at a defined end-point of degradation (usually more than 96 h) whereas the CNCPS Prot C is assumed to be the ADIN. It is possible the NRC (2001) Prot C is greater than the CNCPS Prot C because the CNCPS Prot C assumes a theoretical indigestible feed protein (ADIN). The NRC (2001) Prot A for extruded soybean and the CPM-Dairy Prot C for Soy Best with Gums were used. The NRC (2001) Prot B was computed by difference.

Determination of the Passage Rate

Both models (CNCPS-based nutrition models and the NRC (2001)) use a predicted fractional passage rate (kp) to compute RDP. In the CPM-Dairy, kp is used for Prot B1, B2, and B3 whereas in the NRC (2001) the kp is used for Prot B.

Note the NRC (2001) has incorrect equations for passage rate. The correct equations were shown by Seo et al. (2006b) and are shown in Box 1. Further analysis of passage rate data led to the

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development of a new set of equations that were published by Seo et al. (2006a), which are shown in Box 2.

$$\text{Kp for dry forage} = 3.362\ (\pm\ 0.263) + 0.479\ (\pm\ 0.052)\ \text{DMIpBW} - 0.017\ (\pm\ 0.004)\ \text{NDFF} + 0.007\ (\pm\ 0.002)\ \text{ConcpDM};$$

$$\text{Kp for wet forage} = 3.054\ (\pm\ 0.393) + 0.614\ (\pm\ 0.126)\ \text{DMIpBW};$$

$$\text{Kp for concentrate} = 2.904\ (\pm\ 0.516) + 1.375\ (\pm\ 0.177)\ \text{DMIpBW} - 0.020\ (\pm\ 0.006)\ \text{ConcpDM};$$

where DMIpBW = DMI as a percentage of BW, ConcpDM = concentrate content of the diet, % DM, and NDFF = NDF of forage feedstuff, % DM.

Box 1. Correct fractional passage rates of the NRC (2001) model.

$$K_p \text{ for forage} = \frac{2.365(\pm 0.15) + 0.0214(\pm 0.008)\text{FpBW} + 0.0734(\pm 0.007)\text{CpBW} + 0.069(\pm 0.01)\text{FDMI}}{100}$$

$$K_p \text{ for concentrate} = \frac{1.169(\pm 0.36) + 0.1375(\pm 0.016)\text{FpBW} + 0.1721(\pm 0.018)\text{CpBW}}{100}$$

$$K_p \text{ for liquid} = \frac{4.524(\pm 0.33) + 0.0223(\pm 0.027)\text{FpBW} + 0.2046(\pm 0.015)\text{CpBW} + 0.344(\pm 0.005)\text{FDMI}}{100}$$

where K_p is the fractional rate of passage, h^{-1}; FpBW the forage DMI as a proportion of BW, g/kg BW; CpBW the concentrate DMI as a proportion of BW, g/kg BW and FDMI is the forage DMI, kg.

Box 2. Re-developed fractional passage rates using the NRC (2001) model.

Determining an Equivalency of the Protein Systems

Both systems (CNCPS-based models and the NRC (2001)) are not fully equivalent. Each has specific assumptions that prevent them to obtain the same results, even though the results are quite similar most of the times. Further comparison was performed by Lanzas et al. (2007) and a new scheme has been proposed to overcome known limitations of these systems (Lanzas et al., 2008).

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An equivalency between the CNCPS-based models and the NRC (2001) can be achieved based on the calculation of the RDP for each system. Box 3 shows the equations to compute the equivalency. The following assumptions were made:

- The NRC (2001) Prot A for extruded soy is 8.7% CP which is less than the CPM-Dairy Prot A plus B1 = 4.886 + 4.194 = 9.08 % CP. The 8.7% CP was used.
- The NRC (2001) Prot C is equal to CPM-Dairy Prot C = 1.629
- The NRC (2001) Prot B was computed by difference (100 – 8.7 – 1.629) = 89.671 % CP which is slightly greater than the CPM-Dairy Prot B2 plus B3 = 73.656 + 15.635 = 89.291 % CP. The 89.671 % CP was used.

Note that the NRC (2001) Prot C for soybean products ranges from zero to 0.7% of CP depending on the feed type and processing level.

This is the calculation of RDP for the CNCPS-based model:

$$\text{Eq1} = \text{CNCPSRDP} == \text{CNCPSProtA} + \text{CNCPSProtB1}\left(\frac{\text{CNCPSProtB1Kd}}{\text{CNCPSProtB1Kd} + \text{FeedKp}}\right) + \text{CNCPSProtB2}\left(\frac{\text{CNCPSProtB2Kd}}{\text{CNCPSProtB2Kd} + \text{FeedKp}}\right) + \text{CNCPSProtB3}\left(\frac{\text{CNCPSProtB3Kd}}{\text{CNCPSProtB3Kd} + \text{FeedKp}}\right);$$

This is the calculation of RDP for the NRC (2001) model:

$$\text{Eq2} = \text{NRCRDP} == \text{NRCProtA} + \text{NRCProtB}\left(\frac{\text{NRCProtBKd}}{\text{NRCProtBKd} + \text{FeedKp}}\right);$$

Assuming CNCPS_RDP = NRC_RDP and assigning the CNCPS protein and kd valuesThis is the calculation of RDP for the CNCPS-based model:

$$\text{Eq3} = \text{CNCPSProtA} + \text{CNCPSProtB1}\left(\frac{\text{CNCPSProtB1Kd}}{\text{CNCPSProtB1Kd} + \text{FeedKp}}\right) + \text{CNCPSProtB2}\left(\frac{\text{CNCPSProtB2Kd}}{\text{CNCPSProtB2Kd} + \text{FeedKp}}\right) + \text{CNCPSProtB3}\left(\frac{\text{CNCPSProtB3Kd}}{\text{CNCPSProtB3Kd} + \text{FeedKp}}\right) == \text{NRCProtA} + \text{NRCProtB}\left(\frac{\text{NRCProtBKd}}{\text{NRCProtBKd} + \text{FeedKp}}\right);$$

$$\text{Eq4} = \text{NRCProtA} == 8.7;$$

$$\text{Eq5} = \text{NRCProtB} == 100 - (8.7 + 1.629);$$

$$\text{Eq6} = \text{NRCProtC} == 1.629;$$

Box 3. Equations to compute equivalency between systems

Assuming the values of protein fractions described above and solving the equations shown in Box 3 for the NRC (2001) Prot B kd, we obtained the following equation.

$$\text{ProtB2 Kd} = 7.78329 - 0.040798\ \text{FeedKp} - \frac{0.469623}{0.515031 + \text{FeedKp}} - \frac{844.162}{138.571 + \text{FeedKp}}$$

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Unfortunately, the equation above depends on the feed kp. Assuming a range of feed kp ranging from 5 to 10%/h, the following relationship between NRC (2001) Prot B kd and feed kp were obtained.

Providentially, the variation of the NRC (2001) Prot B kd is negligible from 5 to 10% feed kp and therefore, a value of 1.64 %/h for kp of 8% is suggested (Figure 2).

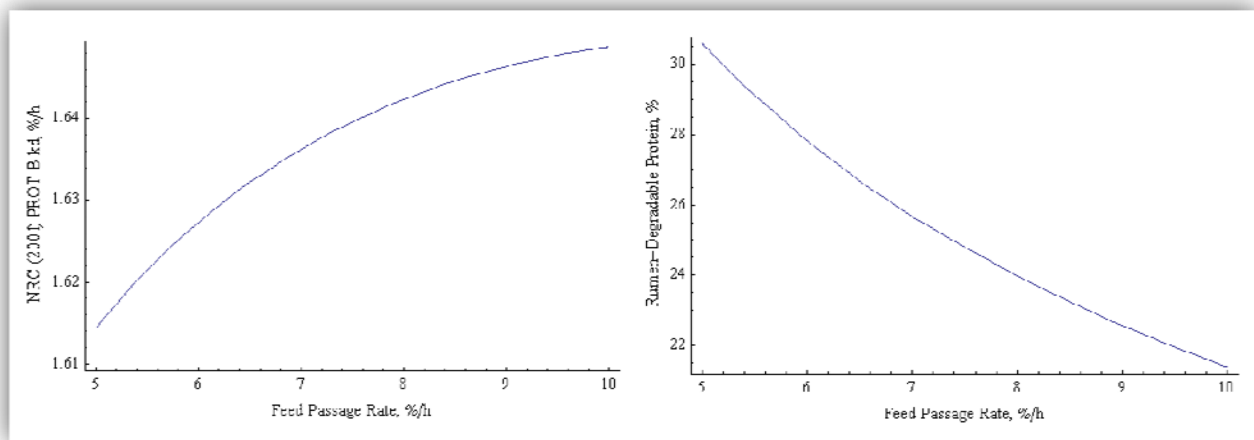

Figure 2. Predicted NRC (2001) Prot B Kd (left panel) and Predicted RDP depending on feed kp.

Therefore, these are the recommendations for Soy Best with Gums information for the NRC (2001).

- Prot A = 8.7 % CP
- Prot B = 89.671 % CP
- Prot B kd = 1.64 %/h
- Prot C = 1.629 % CP

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