

Rumen Degradability and Model Prediction of Nutrient Supply to Ruminants from Different Processed Soybean Meals

Research Article

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ABSTRACT

DVE₂₀₁₀ system was used for model prediction of nutrient supply to ruminants from soy bean meal (SBM), extruded soy bean meal (SBE) and full-fat soybean meal (FSBM). Extruded soy bean meal had the highest truly absorbed rumen undegraded protein in the small intestine (ARUP) followed by SBM and FSBM. There was no significant difference between SBE and FSBM in the case of truly absorbed rumen synthesized microbial protein (AMCP) in the small intestine and largest possible microbial protein synthesis, based on the available amount of energy at rumen level (MCPe) but SBM had a higher AMCP and MCPe compared to the other soy bean meal sources. Endogenous protein loss (ECP) was highest in SBE while there was no significant difference between SBM and FSBM in ECP. Extruded soy bean meal had highest total metabolizable protein (DVE) followed by SBM and FSBM. Modeling nutrient supply to dairy cows using DVE₂₀₁₀ system can offer valuable quantitative data on total amount of true protein digested in the small intestine from different sources which may be used to formulate diets to lower hazardous consequences of nitrogen leakage to environment.

KEY WORDS DVE/OEB system, feed processing, protein evaluation, ruminants, soybean meal.

INTRODUCTION

Soybean meal (SBM) is widely used as a protein supplement in dairy diets. Soybean products are characterized by high palatability and well-balanced and available essential amino acid (EAA) contents. Among the 11 protein sources evaluated, the EAA index of soybean bypass protein is the second best after microbial protein (Chandler, 1989) but extensive ruminal degradability (74% for whole soybeans and 71% for SBM; NRC, (2001)) limits the utilization of these soybean products by ruminants as sources of rumen-undegradable protein (RUP). Various methods have been used to treat soybean products to alter their ruminal degradability and consequently increase their escape protein content. For many years different physical and chemical methods have been researched to reduce rumen protein degrad-

ability and to increase the amino acid supply to the intestine. Extrusion (Benchaar and Moncoulon, 1993; Stern *et al.* 1985) and roasting (Lykos and Varga, 1995) caused a higher flow of total amino acids to the intestine while minimizing the activity of anti-nutritional factors. Improvements of milk yield in response to heat-treated soybeans were obtained in some studies (Faldet *et al.* 1991; Kim *et al.* 1993; Schingoethe, 1996), but other studies (Driver *et al.* 1990; Chen *et al.* 2002) did not show any improvement. Based on an increased knowledge gained about the nitrogen metabolism in the ruminants during recent years and the shortcomings of the present systems based on digestible, true or crude protein, several new protein evaluation systems have been proposed (Hvelplund and Madsen, 1993). Although the basic frameworks of all the proposed new systems are similar, the units and factors

used to calculate the protein values differs (Hvelplund and Madsen, 1993). There are several advanced models such as French PDI system, UK system “Feed into milk” (Thomas, 2004), the NorFor-system (Volden and Nielsen, 2011), NRC (NRC, 2001) and DVE/OEB (Tamminga *et al.* 1994; Van Duinkerken *et al.* 2011) which might be used to quantitatively predicted protein nutrient supply to dairy cows, both in the rumen and intestines (Yu *et al.* 2003b). The Dutch DVE system is based on the French PDI system (Tamminga *et al.* 2007). In this system each feed has a DVE value, expressing the protein supply to the host animal, composed of the digestible true protein contributed by RUP, microbial crude protein synthesized in the rumen and a correction for endogenous CP losses in the digestive tract. Each feed also has a degraded protein balance onbestendig eiwit balans (OEB) reflecting the (im) balance between microbial protein synthesis potentially possible from rumen-degradable protein (RDP) and that potentially possible from the energy obtained by anaerobic fermentation in the rumen (Van Duinkerken *et al.* 2011). With the DVE/OEB model, it is possible to predict the potential nutrient supply to the animal from protein feedstuff as affected by heat processing (Yu *et al.* 2002a) and even it could be enlightening to re-interpret the results of *in vivo* studies in terms of DVE/OEB model as implied by Yu *et al.* (2001). The Dutch DVE system has been used for modelling of nutrient supply to ruminants from different processed feedstuff (Doiron *et al.* 2009; Froidmont *et al.* 2008; Yu *et al.* 1999; Yu *et al.* 2002a; Yu *et al.* 2000). New findings during the recent years have been used to update the DVE/OEB system which can potentially improve the accuracy and precision of predictions by allowing simultaneous consideration of multiple effects in models. Recently an update of DVE/OEB (DVE₂₀₁₀) model was published (Van Duinkerken *et al.* 2011). Although the terms and terminology of concepts are similar in this system with the earlier system (DVE₁₉₉₄; Tamminga *et al.* 1994), the DVE₂₀₁₀ system uses a different approach to estimate the truly absorbable protein supply to small intestine and degraded protein balance in the rumen. The aim of this study was to compare ruminal crude protein degradation kinetics and modelling potential nutrient supply to ruminant animals between soybean meal, extruded and full-fat soybean using the DVE/OEB₂₀₁₀ system.

MATERIALS AND METHODS

Samples and chemical analysis

In this study, commonly locally used soybean products for dairy cattle, including soybean meal (SBM), extruded soybean meal (SBE) and full-fat soybean (FSBM) were investigated.

Samples from these feeds were provided by local distributors. One half of each sample was ground for laboratory analysis and another half was stored as backup at -20 °C. Laboratory samples of the feedstuffs and rumen residues were prepared by grinding to pass a 1 mm screen. The dry matter (DM; AOAC official method 930.15), Ash (AOAC official method 942.05), crude fat (EE; AOAC official method 954.02) and crude protein (CP; AOAC official method 984.13) contents were analyzed according to the procedures of AOAC (1990). The acid detergent fiber (ADF) and neutral detergent fiber (NDF) values were analyzed according to the procedures of Van Soest *et al.* (1991). Neutral detergent fiber was determined without sodium sulfite. Chemical composition and characteristics of the samples are provided in Table 1.

Table 1 Chemical composition and nutrient profiles of tested feedstuffs

Chemical composition	Feedstuffs		
	SBM	SBE	FSBM
DM (g/kg)	932.0	941.2	943.2
CP (g/kg DM)	432.2	484.0	352.1
EE (g/kg DM)	18.5	74.3	197.6
Ash (g/kg DM)	70.0	61.8	56.7
NDF (g/kg DM)	155.1	194.1	211.7
ADF (g/kg DM)	101.1	104.5	100.3
RNSP (g/kg DM)	277.5	137.0	178.2
FOM (g/kg DM)	61.9	50.0	50.3

SBM: soybean meal; SBE: extruded soybean meal; FSBM: full-fat soybean; ADF: acid detergent fiber; ADICP: acid detergent insoluble crude protein; CP: crude protein; DM: dry matter; EE: ether extract; FOM: fermented organic matter; NDF: neutral detergent fiber; NDICP: neutral detergent insoluble crude protein; NFC: none fiber carbohydrate; RNSP: residual non-starch polysaccharides.

In situ incubations

The degradation characteristics of the feedstuffs were estimated with the *in situ* technique of Ørskov and McDonald (1979) as adapted by Netherlands Centraal Veevoeder Bureau (CVB), but with 96 h instead of 336 h as prolonged incubation time point. This study was conducted in 2 experimental runs and, in each run, the treatments were randomly assigned among the 3 Holstein dairy cows (weight 605 ± 15.6 kg and 27 ± 2.5 kg/d milk production) fitted with a large rumen cannula with an internal diameter of 10 cm were used for measuring rumen degradation characteristics. Cows were housed individually in the Dairy Research Building at the Ferdowsi University of Mashhad, during *in situ* rumen incubation time. Cows were fed according to NRC (2001) recommendations for their milk production level. Ration was based upon corn silage, alfalfa hay and mixed concentrate consisting of barley grain, corn grain, soybean meal, canola meal, cotton seed meal, micro-mineral premix, vitamin premix A and D, limestone, and

salt. Animals were fed in the form of TMR daily at 06:00, 14:00 and 22:00 h right after milking. The incubation time points were 0, 2, 4, 8, 12, 24, 48, 72 and 96 h. The “gradual addition/all out” method was followed. The 0-h samples were treated in the laboratory according to the procedure of Azarfar *et al.* (2007) to determine the soluble and insoluble washable fractions.

After incubation, bags were removed from the rumen and washed in a bucket with cold tap water to remove excess ruminal contents. Subsequently, bags were dried at 70 °C for 48 h. Dried samples were stored in a refrigerated cool room (4 °C) until analysis. The *in situ* data were fitted in the modified first-order kinetic equation:

$$R(t) = U + D \times e^{-kd \times t}$$

Where:

R(t): residue at t hours of incubation (%).

U: undegradable fraction (%).

D: potentially degradable fraction (%).

t: time of incubation (h).

Kd: degradation rate of potentially degradable fraction (%/h).

In situ parameters were calculated with the NLIN (nonlinear) procedure of SAS software (SAS, 2011).

The DVE₂₀₁₀ system

The amount of true protein digested in the small intestine (DVE) is calculated from the amount of truly absorbed rumen undegraded protein in the small intestine (ARUP), truly absorbed rumen synthesized microbial protein in the small intestine (AMCP) and the endogenous protein losses in the digestive tract (ENDP) in DVE₂₀₁₀ system (Van Duinkerken *et al.* 2011). Requirements of dairy cows are also expressed in units of DVE.

$$DVE = ARUP + AMCP - ENDP$$

Description on concepts and formulas are being presented by Van Duinkerken *et al.* (2011) in detail and different aspects of new considerations regarding to degradation of feed components in the rumen, the fractional degradation rates of the non-washout potentially degradable fraction, the efficiency of MPS and nylon bag incubation procedure fractionations are thoroughly described in that paper.

Concisely the DVE fraction obtained from rumen undegraded protein (RUP) was calculated from the amount of feed protein that escapes degradation in the rumen multiplied by digestibility of undegraded protein in the small intestine while the relative amount of RUP was calculated as:

$$\% \text{ RUP} = Kp_s / (Kd_s + Kp_s) \times S + Kp_{w-s} / (Kp_{w-s} + kd_D) \times (W-S) + Kp_D / (Kp_D + kd_D) D + U$$

Where:

S: soluble CP fraction (%)

(W-S): CP in small particles fraction, calculated as the difference between W and S.

W: washable CP fraction (%)

D: potentially degradable CP fraction (%) (D=100-W-U)

U: undegradable CP fraction (%)

Kp_s: rate of passage from the rumen of the S fraction, assuming 11 %/h.

Kp_{w-s}: rate of passage from the rumen of the (W-S) fraction, assuming 8 %/h.

Kp_D: rate of passage from the rumen of the D fraction, assuming 6 %/h.

Kd_s: rate of degradation of CP in the S fraction in the rumen, assuming 200 %/h.

kd_D: rate of degradation of CP in the D and (W-S) fraction in the rumen (%/h).

Determination of DVE fraction obtained from AMCP in DVE₂₀₁₀ system is rather advanced and complex. It is assumed that the proportions of the various chemical feed components that are degraded in the rumen result from fractional degradation and passage rates per fraction within the component as outlined below:

$$FCOMP = COMP \times \{S \times kd_s / (kd_s + kp_s) + (W-S) \times kd_{(w-s)} / (kd_{(w-s)} + kp_{(w-s)}) + D \times kd_D / (kd_D + kp_D)\}$$

Where:

FCOMP: component fermented in the rumen (g/g DM).

COMP: content of the relevant part (g/g DM).

S: water-soluble fraction after filtration or centrifugation (g/g).

kd_s: fractional rate of degradation of fraction S (/h).

kp_s: fractional rate of passage out of the rumen of fraction S (/h).

W: fraction washed out of nylon bags (g/g).

(W-S): insoluble washout fraction (g/g).

kd_(w-s): fractional rate of degradation of fraction (W-S) (/h).

kp_(w-s): fractional rate of passage out of the rumen of fraction (W-S) (/h).

D: non-washout potentially degradable fraction (g/g).

kd_D: fractional rate of degradation of fraction D (/h).

kp_D: fractional rate of passage out of the rumen of fraction D (/h).

As DVE₂₀₁₀ considers a specific microbial protein yield for each fraction in this formula, the fermentable organic

matter and MCP was calculated as the sum of FCOMP and its related microbial protein yield. In order to calculate true digestibility of microbial protein, MCP was being multiplied by its digestibility (85%) and true protein content of MCP (75%) as assumed in DVE₂₀₁₀. Calculation of last fraction of DVE is based on the assumption that 75 grams of endogenous protein losses in the digestive tract (ENDP) will occur per kilogram of undigested DM (UDM) where UDM was calculated as undigested organic matter (UOM) plus undigested ash (UASH).

Degraded protein balance

Rumen degraded protein balance (OEB) in the DVE system (in Dutch: onbestendig eiwit balans) represents the difference (at rumen level) between the maximum possible microbial protein synthesis, based on the available amount of degradable protein on one hand and the maximum possible microbial protein synthesis, based on the available amount of energy on the other.

$$\text{RDPB} = \text{MCP}_n - \text{MCP}_e$$

Where:

MCP_n: maximum possible microbial protein synthesis based on available nitrogen.

MCP_e: maximum possible microbial protein synthesis based on available energy.

Statistical analysis

Statistical analyses were performed using the MIXED procedure of SAS software using the following model:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where:

Y_{ij}: observation of the dependent variable ij.

μ: population mean for the variable.

α_i: effect of the treatments.

e_{ij}: random error associated with observation ij.

The significant level for all statistical analyses was declared at (P<0.05) and trends at (P<0.15). Treatment means were compared using the Tukey test.

RESULTS AND DISCUSSION

In situ degradation kinetics

In situ ruminal crude protein degradation kinetics of tested samples are presented in Table 2. Extruded soybean meal had the highest washout fraction followed by SBM and FSBM while SBP had the lowest washout fraction. Values obtained in this study for W and D fraction are similar to

values reported by several researchers (Froidmont *et al.* 2008; Hvelplund and Madsen, 1993; Lin and Kung, 1999; Schingoethe, 1996) but degradation rate per hour is lower than the most of these reports (Froidmont *et al.* 2008; Hvelplund and Madsen, 1993; Lin and Kung, 1999) and is like that reported by Schingoethe (1996) and NRC (1989).

High levels and rates of degradability of CP in SBM could be due to the structure and solubility characteristics of protein in SBM which could be easily attached by microorganisms in the rumen (Mahadevan *et al.* 1980). Effective degradability of CP in raw soybean has reported to be between 62.3 to 98 percent (Yu *et al.* 2002b). Discrepancies in reported values could be attributed to differences in the nature of incubated meal as well as *in situ* technique, basal diet or variation in the extent of microbial contamination of the incubated samples (Thomas, 2004; Volden and Nielsen, 2011). Extruded soybean meal had higher W and lower D and kd values compared to SBM. Extruding consists of passing dry whole seeds through tapered screw(s) in a fixed metal barrel. The screws convey the ground material from the feed end of the barrel to the die(s), cooking it by heat due to friction and shear, and extra heat applied to the barrel (Melcion and Van der Poel, 1993). As the material exits the die, steam derived from the moisture content is flashed due to pressure differential expanding the feed material. The combination of temperature, pressure, moisture and shear, followed by expansion when the material leaves the barrel, changes the properties of the material, including its digestive behavior in the rumen (Yu *et al.* 2002a). Few estimates of CP degradability of SBE are available for comparison (Yu *et al.* 2002a) but the same pattern has been reported by Yu *et al.* (2003a) who observed SBE had relatively higher W and lower D and kd compared to SBM. Fraction A for SBE in this experiment was higher than the range of 6.5 to 11.6% for SB extruded at temperatures of 165 and 145 °C, respectively (Yu *et al.* 2002c) and that reported by Yu *et al.* (2003a). In contrast Nowak *et al.* (2005) who compared degradation parameters of dry matter and crude protein of extruded soybeans reported an increase in D and decrease in W fractions for extruded soybean compared to untreated soybean. In that study extruded soybeans had lower kd compared to untreated soybean which is in agreement with our results. Several authors have sought to understand the effect of heat treatment on degradation dynamics by studying the protein structure of evaluated feeds and proteins present in the residues after fermentation. White lupin, soybean meal and rapeseed meal contain two main types of proteins: albumins (soluble in water) and globulins (soluble in saline solutions) (Duranti *et al.* 1981; Aufrère *et al.* 1994; Van Barneveld, 1999; Sadeghi and Shawrang, 2006). Extrusion can modify the protein structure by destroying many covalent and non-covalent bonds

that would stabilize the secondary structure while new intermolecular bonds can form to create sub-units (Lampart-Szczapa *et al.* 2006).

Table 2 *In situ* ruminal crude protein degradation kinetics of tested feedstuffs

Feedstuffs	Degradation kinetics ²			
	W	D	Kd	ED (kp=0.06)
SBM	11.9 ^b	86.7 ^a	0.062 ^b	53.6 ^a
SBE	18.8 ^a	80.5 ^b	0.038 ^c	46.3 ^b
FSBM	18.2 ^a	76.6 ^c	0.078 ^a	57.8 ^a
SEM	2.23	1.21	0.004	2.11

The means within the same column with at least one common letter, do not have significant difference ($P>0.05$).

SBM: soybean meal; SBE: extruded soybean meal; FSBM: full-fat soybean W: fraction disappeared by washing the bags; D: potentially rumen degraded fraction; kd: degradation rate per hour; kp: passage rate per hour; ED: effective degradability $(0.8 \times W) + (D \times kd) / (kd + kp)$.

SEM: Standard error of the means.

Full-fat soybean meal is produced by roasting the whole soybeans and it has high fat levels. Comparable estimates of CP degradability of FFSB are also limited and inconsistent (NRC, 2001; Schingoethe, 1996; Yu *et al.* 2001). Present estimates for W, D and kd are like that reported by Schingoethe (1996) and NRC (1989) while Kamalak *et al.* (2005) has reported a considerably higher W and lower kd for FSBM compared to others. Heat treatment of soybean meal (SBM) reduces CP solubility and rumen ammonia levels (Tagari *et al.* 1962), rumen *in situ* nitrogen (N) degradation and augments flow of dietary amino acids to the small intestine (Glimp *et al.* 1967; Nishimuta *et al.* 1974). The mechanism of altering the derivative behavior of protein, as described by Goelema *et al.* (1999), with heat treatments involves principally denaturation (which is a disorganization of the overall molecular shape of a protein); unfolding or uncoiling of a coiled or pleated structure, or the separation of the protein into its subunits, which may then unfold or uncoil (Holum, 1982). Heating changes chemical profiles, protein structure α -helix to β -sheet ratio, and protein sub-fractions; decreases rumen-degradable protein and rumen-degradable dry matter and increased potential nutrient supply to dairy cattle (Doiron *et al.* 2009). Any temperature change in the environment of the protein which can influence the non-covalent interactions involved in the structure may lead to an alteration of the quaternary, tertiary and secondary structure. More extreme forms of processing may lead to the destruction of the primary structure, often called 'degradation' of protein. It is obvious that not only temperature during treatment plays a role, but also factors such as residence time and moisture level. Reactions of the Maillard type are very common (Hurrell and Finot, 1985). These include non-enzymatic browning, involving condensation reactions between primary amines and reducing sugars, followed by isomerization and polymerization of the products formed. Epsilon amino groups of lysyl resi-

dues are the most reactive amines in proteins. Other reactions also occur (Goelema *et al.* 1999) including the formation of isopeptide cross-links between lysine residues and asparagine and glutamine. Additionally, methionine, cystine and tryptophan might be involved (Broderick *et al.* 1991). Reduction in effective degradability (ED) of SBE might be related to high temperatures involved in extrusion process and the fact that excessive heat treatment can reduce protein degradability in the rumen of dairy cows (Ljøkjel *et al.* 2000). Although FSBM is also heat-treated to some extent, ED of protein tended to be higher ($P<0.12$) which is probably the result of high NDF content in FSBM in present study and relatively high NDIN content of Iranian SBM (Nasri *et al.* 2008).

DVE₂₀₁₀ predictions

The predictions of the potential protein supply (g kg^{-1} DM) to dairy cows from tested samples, using the DVE₂₀₁₀ system are presented in Table 3.

Table 3 The predictions of the potential protein supply (g kg^{-1} DM) to dairy cows from tested feedstuffs using DVE₂₀₁₀ system

Parameter	Feedstuffs			SEM
	SBM	SBE	FSBM	
ARUP	194.5 ^b	279.6 ^a	131.7 ^c	21.42
AMCP	57.9 ^a	46.5 ^b	46.5 ^b	1.89
ECP	23.4 ^c	25.8 ^b	27.0 ^a	0.52
DVE	228.9 ^b	300.3 ^a	151.3 ^c	21.52
MCPn	231.5 ^a	200.8 ^c	211.3 ^b	4.52
MCPe	90.8 ^a	72.9 ^b	73.0 ^b	2.97
DPB	140.7 ^a	127.9 ^b	138.4 ^a	2.01

The means within the same row with at least one common letter, do not have significant difference ($P>0.05$).

SBM: soybean meal; SBE: extruded soybean meal; FSBM: full-fat soybean; AMCP: truly absorbed rumen synthesized microbial protein in the small intestine; ARUP: truly absorbed rumen undegraded protein in the small intestine; DPB: degraded protein balance; DVE: true protein digested in the small intestine; ECP: endogenous protein loss; MCPe: maximum possible microbial protein synthesis, based on the available amount of energy at rumen level and MCPn: available amount of degradable protein.

SEM: Standard error of the means.

SBE had the highest ARUP followed by SBM and FSBM. This is not surprising since SBE had lowest ED. SBM had higher MCPe while there was no significant difference between SBE and FSBM for MCPe. The fact that although SBE had lower ED compared to FSBM, there was no significant difference in their MCPe is due to the approach used by DVE₂₀₁₀ for calculation of MCPe. In the DVE₂₀₁₀ system, the washout fraction is separated into soluble (S) and insoluble (W-S) washout fractions. Of the S fraction, a proportion of 0.05 (5 %/h) is assumed to escape degradation in the rumen. Also a significant but variable proportion of the W-S fraction will escape (Van Duinkerken *et al.* 2011). There was no significant difference between SBE and FSBM in the case of AMCP and consequently MCPe but SBM had a higher AMCP and MCPe compared to those. SBE had highest DVE followed

by SBM and FSBM. Beside all the differences in protein degradation kinetics caused by different processing methods, DVE could be the best reflector of how animal benefits from a protein source. In a study conducted by Doiron *et al.* (2009), modeling results showed that heating increased total intestinally absorbable protein (feed DVE value) and decreased degraded protein balance (feed OEB value) of flaxseed and there was a linear effect of heating time on the DVE and a cubic effect on the OEB value. In an *in vivo* study (Froidmont *et al.* 2008) reported that extruded lupin seed had less OEB and more DVE content compared to grinded lupin seed. Similar results have being reported by Yu *et al.* (2002c) who found that heat processed legume seed had less AMCP but markedly higher DVE content compared to raw legume seed. They argued that reduced FOM and rumen protein degradation in heat processed legume seed causes a reduction in AMCP while increased amount of ARUP in that study was enough to compensate for the computed decrease in microbial protein production. Therefore, the net absorbable DVE value in the animal was substantially increased. In present study although the SBE and FSBM had the same fermented organic matter (FOM), AMCP and ED for CP, FSBM had considerably lower ARUP and DVE which might indicate heat damage during the FSBM processing. The protein structure α -helix to β -sheet ratio might be influenced by heat processing and has a significant positive correlation with total intestinally absorbed protein supply and negative correlation with degraded protein balance (Doiron *et al.* 2009). Heat treatment results in structure stabilization and cross linkages to carbohydrates, which protects them from ruminal hydrolysis or at least slows down their rate of degradation. Such linkages are beneficial in the rumen, unless they are not reversible in the intestine (Goelema and Tamminga, 1994; Goelema *et al.* 1999). Endogenous protein loss was highest in SBE while there was no significant difference between SBM and FSBM in ECP. This may reflect the excessive heating during the extrusion process that can change the characteristics of the food and making it more indigestible. Endogenous protein loss in DVE₂₀₁₀ system is considered as a total waste which a part of available protein in the small intestine is needed to replace it while some other systems (i.e. NRC, 2001) consider this as a source of protein which partially could be used by animal. When the OEB value of a feed is positive, it indicates a potential N loss from the rumen and a negative OEB value shows a shortage of N which may impair potential microbial protein synthesis of this feed.

A high OEB values in protein rich feedstuff such as raw lupin seeds, horse beans, peas and soybeans indicates a potential imbalance between feed N degradation and utilization and indicated a potentially large N loss from rumen (Yu *et al.* 2002c). Recent European limitations on the use

of animal protein sources in ruminant diets (94/7381/EC; 95/60/EC) have made it more difficult to meet the rumen non-degradable protein requirements in high producing ruminants. As an alternative, soybean products with their high protein content and good profile of essential amino acids could be used to meet the protein requirements of these classes of ruminants (Yu *et al.* 2001). In a diet with DBP of zero microbial protein synthesis is theoretically maximum (Van Duinkerken *et al.* 2011) and in such a condition protein sources with higher DVE to CP ratio could be beneficiary to avoid overfeeding of nitrogen and reduce the hazardous consequences of nitrogen leakage to environment. All the results reported here is output from a model with inputs based on *in sacco* technique. The challenge is to apply the predictions and evaluate them in an animal performance experiments. However, the number of such studies in this area available to challenge the model is extremely limited. Part of reason is that the information on DVE and OEB values of each feedstuff in the diets, or data from which these are derived is extremely limited. The newly developed DVE/OEB model appears to have characteristics that can provide relatively accurate information on the quantitative aspects of both ruminal and post-ruminal feed protein digestion in ruminants for each feedstuff.

CONCLUSION

SBE and FSBM have different CP degradation characteristics than SBM. Modeling nutrient supply to dairy cows using DVE₂₀₁₀ system can provide valuable quantitative data on total amount of true protein digested in the small intestine from different sources. Such a data might be used to formulate diets to minimize hazardous consequences of nitrogen leakage to environment.

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