SOYBEAN MEAL DIGESTION IN THE RUMEN: AMINO ACID CHANGES

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Story in Brief

Dacron bags containing soybean meal (SBM) or .15 N NaCl extracted SBM (ESBM) were suspended in the rumen for 4, 14 or 24 hr of steers fed a high roughage or high concentrate diet. Undigested samples and digested residues were analyzed for 18 amino acids. Disappearance of total amino acids from bags was greater with the high roughage diet. The pattern of amino acid disappearance from SBM and ESBM appeared to be similar as time of in situ digestion increased and was not affected either by diet or extraction of the soluble protein fraction. If in situ disappearance of N reflects ruminal digestion of SBM protein, SBM that escapes microbial degradation in the rumen should have an amino acid composition similar to that of SBM that is fed.

Introduction

Various models have been proposed to predict the metabolizable protein content of feedstuffs as reviewed in a recent symposium (Owens, 1982). Such models predict protein flow to the small intestine. In the future, these models must be refined to estimate amino acid supply to the small intestine. This task will be considerably less complicated if the amino acid composition of bypassed feed protein has an amino acid composition similar to that of the protein fed. Soluble protein, presumably the more extensively degraded protein, usually differs in amino acid composition from protein of total feedstuffs, so some alteration in amino acid composition might be expected with ruminal digestion. Yet, the soluble fraction is usually a small fraction of the total protein degraded in the rumen. More detailed information concerning the amino acid composition of feed protein escaping destruction in the rumen and reaching the small intestine is needed.

Several methods may be used to evaluate ruminal changes in amino acid composition of feedstuffs. Amino acid composition of digesta leaving the rumen yields an estimate of total output of amino acids from the rumen. Presence of microbial amino acids prevents direct measurement of changes in composition of feedstuff amino acids. By regression, Stern and Satter (1982) suggested that lysine, histidine and arginine were more extensively degraded from dietary protein in the rumen than other amino acids. A more direct approach is to measure the amino acid composition of residues of feedstuffs remaining after digestion in the rumen in dacron bags. These values rely on the assumption that the degree of microbial amino acid contamination of the washed residues following removal from the rumen is minor.

The objective of this study was to evaluate the change over time in amino acid composition of SBM and of SBM with the soluble protein removed (ESBM) when these materials were suspended in the rumen of steers. Steers were fed either a roughage or a concentrate diet and

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nucleic acids were measured in certain residues to evaluate the extent of attachment of microbial nitrogen.

Materials and Methods

Four ruminally cannulated Hereford steers (1400 lbs) were fed every 6 hr at a daily dry matter intake equal to 1.8 percent of body weight. Two animals were fed a high concentrate diet (C) containing 62 percent dry rolled corn, 14 percent cottonseed hulls, 10 percent soybean meal, 6 percent ground alfalfa hay, 6 percent molasses and 1.5 percent minerals. The other two steers were fed a high roughage diet (R) containing 83 percent ground prairie hay, 16 percent soybean meal and 1.2 percent minerals. Both diets contained 13 percent crude protein.

Triplicate dacron bags containing substrates of SBM or SBM which had been extracted with .15 N NaCl for 6 h (ESBM) were suspended in the rumen of each of the 4 steers for 4, 14 or 24 hr. After removal from the rumen, bags were thoroughly washed and dried for 48 hr at 55 C. The residues removed from duplicate bags as well as undigested substrates were analyzed for concentrations of 18 amino acids. Relative and total disappearance of amino acids were calculated from analyses of the undigested substrates and digested residues. Relative amino acid disappearance from SBM and ESBM reflects the amino acid contribution of the soluble protein fraction. In addition, certain residues of ESBM remaining after 4 or 14 hr ruminal exposure were subjected to nucleic acid analysis to assess the degree of contamination of residues by attached bacteria. To determine the nature of the ruminal environment, ruminal contents were sampled 1 and 3 hr after feeding for pH and ammonia measurement.

Results and Discussion

Ruminal ammonia nitrogen (N) and pH tended to be elevated by roughage feeding (12.3 vs 10.9 mg NH_4-N/dl and 6.42 vs 5.98). Ruminal ammonia levels were in excess of estimated requirements for efficient protein synthesis and organic matter digestion by microorganisms (Weakley and Owens, 1983). Nucleic acid content of selected samples of ESBM, obtained before and after 4 or 14 hr of digestion, is shown in Table 1. Nucleic acids were detected in the initial feedstuffs as expected, but levels generally were low. Residues remaining after 14 hr in situ digestion demonstrated only a slight increase in nucleic acid content over the basal amount in ESBM, while no increase was seen at 4

Table 1. RNA-N content of NaCl extracted soybean mean and residues following digestion in the rumen.

	Digestion time in situ, hr		
	0	4	14
RNA-N, % of dry matter	.099	.102	.192
RNA-N, % of total nitrogen	1.12	1.12	2.34

hr. Assuming 20 percent of bacterial N is nucleic acid N results indicate that the increase in microbial N contamination of ESBM in the well rinsed residue did not exceed 6 percent of the feed N.

Disappearance of amino acids is shown in Figure 1. As suggested previously (Weakley et al., 1983a), disappearance of amino acids from SBM placed in dacron bags and suspended in the rumen was greater with the higher roughage diet. The influence of diet on DM and amino acid disappearance was small at 4 hr but increased in magnitude over time.

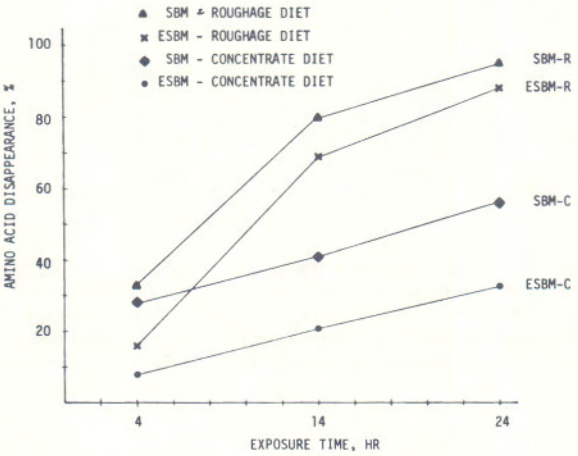

Figure 1. Amino acid disappearance from dacron bags containing soybean meal (▲) or .15N NaCl extracted soybean meal (✖) suspended in the rumen of high roughage fed steers or from dacron bags containing soybean meal (◆) or .15N NaCl extracted soybean meal (●) suspended in the rumen of high concentrate fed steers for 4, 14 or 24 h.

This difference was apparent whether or not the soluble protein fraction had been removed (ESBM). This suggests that with higher roughage diets, increased protein degradation is due to factors other than, or in addition to, the effect of pH on protein solubility. Figure 2 illustrates the close relationship between DM and amino acid disappearance in the rumen ($r=.98$; $N=24$; $P<.01$). Whether a similar relationship exists in the rumen for other feedstuffs is uncertain, but if protein and dry matter are located in similar cellular fractions, this relationship might be expected.

The essential and non-essential amino acid composition (expressed as percentage of total amino acids) of SBM and ESBM, shown in Figure 3, appears little influenced by extraction of the soluble N component. This suggests that SBM soluble protein, when removed, does not greatly alter the amino acid composition of the residue. When only a small fraction of a feedstuff is solubilized, as is the case with SBM, the amino acid composition of the soluble fraction may have little impact on the composition of the larger, insoluble fraction. With proteins having a higher solubility, more change would be expected.

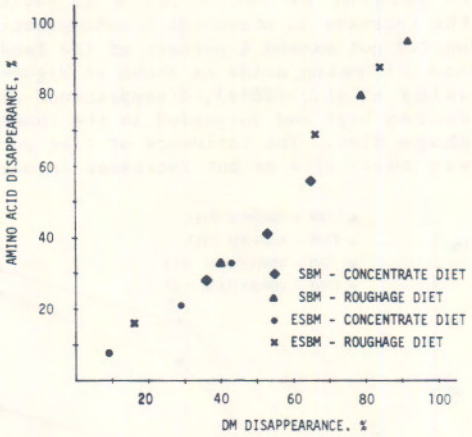

Figure 2. Relationship between DM and amino acid disappearance from dacron bags containing soybean meal (▲) or .15N NaCl extracted soybean meal (✖) suspended in the rumen of high roughage fed steers or from dacron bags containing soybean meal (◆) or .15N NaCl extracted soybean meal (●) suspended in the rumen of high concentrate fed steers for 4, 14 or 24 h

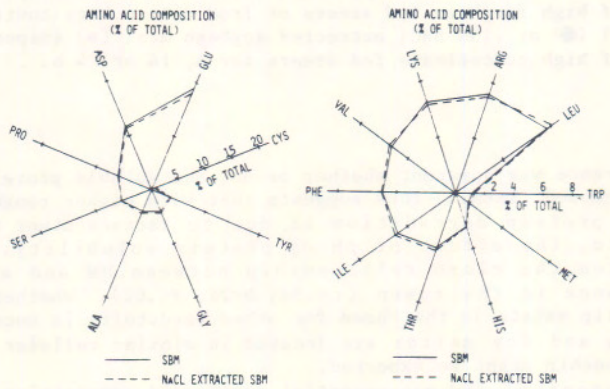

Figure 3. Nonessential and Essential amino acid composition (percentage of total amino acids) of soybean meal (——) or .15N NaCl extracted soybean meal (---).

The survival of essential and nonessential amino acids from either SBM or ESBM exposed in dacron bags in the rumen of steers fed a high concentrate diet is presented in Figures 4 and 5. Results from bags suspended in the rumen of steers fed high roughage diets are not presented since, while the disappearance of all amino acids was greater than observed with the high concentrate diet, the amino acid composition of the residues was similar. The outer, dashed ring of the figures represents the undigested material prior to ruminal digestion. Each ring progressing inward represents an increased residence time in the rumen. Amino acid survival of SBM and ESBM are compared on the same figure with each diet, so that the influence of soluble N extraction on amino acid degradation can be assessed. Degradation was less with the insoluble fraction (ESBM) than with intact SBM since the insoluble fraction represents a fraction generally considered to be less rapidly degraded in the rumen. Washout of this soluble N fraction accounts for the majority of the early (4 hr) disappearance and compositional changes in SBM as reflected by the close proximity of the 0 and 4 hr exposure time rings with ESBM in Figures 4 and 5.

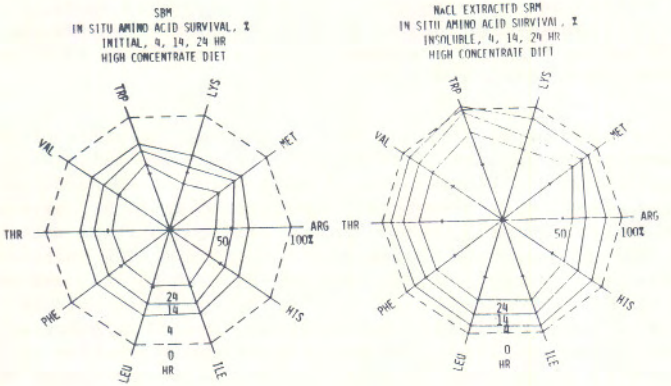

Figure 4. Essential amino acid survival (percentage of initial soybean meal or insoluble .15N NaCl extracted soybean meal amino acid) from soybean meal or .15N NaCl extracted soybean meal placed in dacron bags and suspended in the rumen for 4, 14 or 24 h in steers fed a high concentrate diet.

Concentric rings reflect similar amino acid compositions, while nonconcentric rings reflect shifts in amino acid composition. Visual appraisal of the figures suggests that the rings are generally concentric for both SBM and ESBM, suggesting that amino acid composition changes were minor as digestion progressed. A statistical evaluation of the change in each amino acid's proportion of the total amino acids was performed to detect any selective susceptibility or resistance to ruminal degradation. Low variability among the measurements greatly increased the opportunity for identifying many significant differences, regardless of their biological importance. Preferential disappearance of glutamic acid contributed to a relative increase in other amino acids. Both diet and extraction of SBM with .15 N NaCl influenced the average essential and nonessential amino acid composition of the residues, when considered together. However, differences were small and should be of little biological importance.

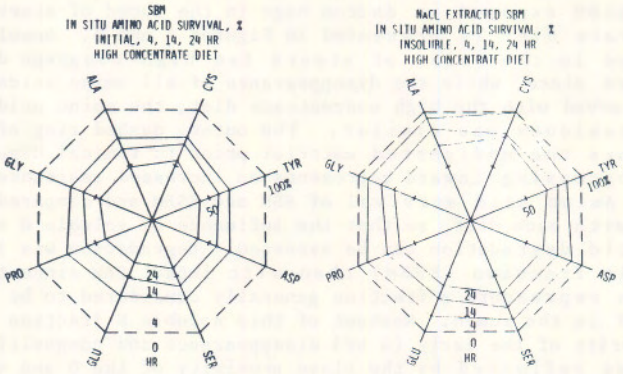

Figure 5. Nonessential amino acid survival (percentage of initial soybean meal or insoluble .15N NaCl extracted soybean meal amino acid) from soybean meal or .15N NaCl extracted soybean meal placed in dacron bags and suspended in the rumen for 4, 14 or 24 h in steers fed a high concentrate diet.

The influence of time and diet on the concentration of each amino acid (expressed as percent of total amino acids) was calculated. Though the magnitude of change was usually small, certain amino acids appeared to be preferentially destroyed. Composition at 24 hr, expressed as a fraction of the predigestion amino acid composition was (percent): arginine 82, histidine and lysine 97, phenylalanine 104, methionine 105, isoleucine and threonine 108, leucine 109, valine 113, and tryptophan 98. Among the nonessential amino acids, glutamic acid recovery was lowest (86) while relative concentrations of glycine and alanine increased (119 and 113). Changes support the suggestion of Stern and Satter (1982) that loss of arginine, histidine and lysine may exceed loss of other amino acids, but our changes were less than one-third as large as their estimates.

Extraction of the soluble protein fraction (ESBM) did not appear to greatly influence these relationships, supporting the contention that, with SBM, more complete ruminal digestion of the more soluble protein fraction has little impact on the amino acid composition of ruminally digested residues.

In summary, while diet appeared to influence the total quantity of amino acids disappearing from SBM in dacron bags, neither diet or extent of digestion appeared to greatly influence amino acid composition. Whether these relationships exist for other feedstuffs remains to be determined.

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