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Disappearance of amino acids from the gastro-intestinal tract of dairy cows fed soyabean meal or fish meal diets*

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ABSTRACT

Four German Friesian cows, fitted with cannulas in the rumen, duodenum and ileum, were fed on diets containing similar amounts of rumen-degradable organic matter and crude protein, and soyabean meal or fish meal as the major protein source. The disappearance of organic matter, nitrogen and amino acids (AA) from the stomachs and from the small and large intestines was determined. Digestibilities of organic matter, nitrogen and AA in the stomachs were similar for both diets. A trend was observed for greater disappearance of these components from the small intestine of cows fed the fish meal diet. The comparison of the AA composition of duodenal digesta with that of the diets indicated that ruminal fermentation altered the AA profile of fish meal less than that of soyabean meal. Disappearance of individual AA from the small intestine differed within and between diets. Preferential disappearance of essential AA from the small intestine compared with non-essential AA was observed. We conclude that the protein value of feedstuffs in terms of absorbed AA should be evaluated separately for feedstuff and individual AA.

KEY WORDS: dairy cow, amino acids, disappearance, gastro-intestinal tract, fish meal, soyabean meal

* In honour of Prof. Dr. Dr. K. Drepper

INTRODUCTION

Amino acids (AA) are supplied to the duodenum of dairy cows by microbial protein synthesized in the rumen, rumen-undegraded dietary protein and endogenous protein. On average, microbial nitrogen (N) supplies 59% of the non-ammonia-N (NAN) in duodenal digesta of dairy cows (Clark et al., 1992). Therefore, the AA composition of protein in duodenal digesta should reflect that of microbial protein. From a survey of literature data, Merchen and Titgemeyer (1992) concluded that proportions of individual essential AA (EAA) in duodenal digesta are not greatly divergent from those in ruminal bacteria, except for leucine and lysine. When the extent of ruminal protein degradation, however, is very low or AA release from feeds differs among individual AA or both, AA composition of duodenal digesta may be altered largely due to a greater proportion of rumen-undegraded feed protein. According to Erasmus (1991), manipulations of duodenal AA profile have only been successful when supplemental protein supplied about half of the total dietary protein.

Fish meal (FM) contains high-quality protein (Agricultural Research Council, 1980) with an AA composition close to that required for growth and milk production (Atwal and Erfle, 1992). From studies conducted *in vitro* (Hussein et al., 1991) and *in situ* (Susmel et al., 1989; Petit, 1992; Martillotti et al.,1995), it is obvious that FM protein is more resistant to ruminal degradation than protein from soyabean meal (SBM). Based on the amounts of intestinally absorbed AA, FM has been judged a valuable source of rumen-undegraded protein for rapidly growing steers (Keery et al., 1993). To the authors' knowledge, no studies report on the fate of ruminally undegraded AA from FM within the small and large intestines of dairy cows. Recent developments in protein evaluation systems for ruminants have focused on supply of individual AA to and disappearance from the small intestine to determine individual AA rather than protein requirements of cattle (Iburg, 1993; van Straalen, 1995; Schwab, 1996). The objectives of this study were to compare the AA composition of duodenal digesta and the disappearance of individual AA from the small intestine of dairy cows fed rations containing similar amounts of rumen-degradable organic matter (OM) and CP, but differing in the major CP source, i.e. SBM or FM.

MATERIAL AND METHODS

Animals and diets

Four German Friesian cows (two lactating, two non-lactating) fitted with permanent ruminal, duodenal and ileal cannulas (Brandt et al., 1984), were used.

TABLE 1

Composition of soyabean meal and fish meal diets, % of dry matter

Ingredient	Diet	
	soyabean meal	fish meal
Grass hay	39.1	42.6
Soyabean meal	25.6	–
Fish meal	–	20.9
Tapioca	29.5	31.0
Mineral-vitamin mixture	5.8	5.5

TABLE 2

Chemical composition of dietary ingredients, g/kg of dry matter

Item	Ingredient			
	soyabean meal	fish meal	grass hay	tapioca[1]
Crude protein	530	730	120	24
Acid ether extract[2]	19	52	35	8
Ash	65	192	64	61
Crude fibre	50	16	310	46
Nitrogen-free extractives	337	12	467	861
TAA[3]	553	765	103	
EAA[4], g/100 g AA	44.5	48.6	47.0	
leucine	7.8	8.3	9.8	
lysine	6.6	8.6	5.5	
valine	4.9	5.6	6.8	
arginine	7.8	6.6	5.4	
threonine	4.1	4.8	5.2	
isoleucine	4.4	4.7	4.5	
phenylalanine	5.0	3.9	5.5	
histidine	2.5	3.0	1.9	
methionine	1.3	3.0	2.4	
NEAA[5], g/100 g AA	55.5	51.4	53.0	
glutamic acid	18.2	14.0	12.0	
aspartic acid	11.4	10.5	10.7	
glycine	4.4	7.1	5.7	
alanine	4.3	6.1	7.3	
tyrosine	3.5	3.1	3.8	
serine	4.9	5.2	4.9	
proline	7.5	4.2	5.6	
cystine	1.4	1.3	3.0	

[1] not analysed for amino acids because of low crude protein content
[2] acid hydrolysis prior to extraction
[3] total amino acids
[4] essential amino acids
[5] non-essential amino acids

Two diets were formulated to provide identical amounts of rumen-degradable OM and CP in the dry matter (DM) of the diet, but from two different protein sources, SBM or FM. Based on an *in situ* study of Susmel et al. (1989), who estimated CP degradability in cows receiving forage and concentrate in proportions (48:52) similar to those used in this study, rumen-degradable CP was assumed to be 54 and 41% of CP for SBM and FM, respectively. Because the CP content of the SBM was higher than calculated, the SBM contributed about one percentage unit more rumen-degradable CP than FM to the respective diet DM. For the whole diet, this difference was even smaller, because the FM diet contained more rumen-degradable CP from hay as a result of the greater hay proportion in the DM of this diet (Table 1). Due to the principal aim of diet formulation, the ingredient (Table 1) and chemical composition (Table 2) of the diets differed slightly. Soyabean meal or FM contributed 70 and 72% to total dietary CP, respectively. The diets containing the respective protein sources are hereafter referred to as the SBM diet and the FM diet. All feedstuffs were obtained commercially. The grass hay was a second cut from a lowland bog and was fed in the long, unchopped form. Tapioca was offered as a meal. According to the manufacturer's information, the SBM was toasted at 102°C for 20 min. To ensure complete intake, 1.7 and 2.7% (DM basis) propionic acid (10%, v/v) were added to the FM diet in periods 1 and 2, respectively. The daily allotment of feed was offered in two equal meals at 07:00 and 19:00 h. Water was freely available at all times.

Experimental design

The two diets were fed to the cows in a two-period changeover design, i.e. all variables that are reported hereafter are the mean of four observations for each diet unless otherwise indicated. Experimental periods were 27 days long. Days 1 to 18 were for dietary adaptation. Sample collections were on days 19 to 27.

Sample collection

Representative samples of the feedstuffs were obtained from each dietary ingredient, pooled by period and stored at room temperature for subsequent analyses. Feed refusals were collected twice daily, dried at 40°C, pooled by animal over the collection period and stored like dietary ingredients until analyzed. Ruminal fluid was collected on day 20 of period 1 and on day 19 of period 2 and on day 27 of both periods. Samples were taken immediately before the morning feeding (0 h) and at 1, 2, 3, 5 and 8 h after the morning feeding. Collection and storage of ruminal fluid prior to analyses were as described previously (Schröder et. al., 1989). The pH of ruminal fluid was measured

immediately after the sample was taken. Duodenal and ileal digesta were spot sampled at 3- and 6-h intervals, respectively, from day 21 to 26 (Schröder et al., 1989). Total faecal collections and storage of digesta and faeces also were as reported by Schröder et al. (1989).

Marker administration

In order to estimate the flow of digesta through the gastro-intestinal tract, chromium ethylene diamine-tetra-acetic acid (Cr EDTA) was used as a marker. A solution of Cr-EDTA in water (1.108 g Cr/l) was infused continuously into the ventral sac of the rumen at a rate of approximately 1.3 l/day.

Analytical procedures

The DM of feedstuffs and feed refusals was determined by oven-drying at 105°C overnight. The DM of digesta and faeces was estimated by freeze-drying and subsequent oven drying at 105°C. Thawed fresh matter was used for determination of N and ammonia-N (NH_3-N) in ileal digesta and faeces. Freeze-dried digesta and faeces were used for all other analyses. Ruminal fluid, duodenal and ileal digesta and faeces were analyzed for NH_3-N by steam distillation according to Brandt (1979). Nitrogen in feedstuffs, digesta materials and faeces was analyzed by the Kjeldahl procedure (Naumann et al.,1976). Cr-EDTA in infusion solutions, digesta and faeces was analyzed photometrically as described by Brandt and Kühn (1987). Samples of feedstuffs, digesta and faeces for AA analyses were hydrolyzed in 6 M HCl at 132°C in an autoclave for 3 h. For sulphur AA, samples were oxidized with hydrogen peroxide: formic acid (1:9, v/v) at 4°C for 24 h, followed by 6 M HCl at 132°C in an autoclave for 3 h. Amino acids were analyzed by ion-exchange chromatography in an AA analyzer (Model T 339 M; Microtechna, Prague).

Calculations and statistical analysis

Amounts of digesta constituents entering the duodenum and ileum in 24 h were estimated from their ratio to the non-absorbed marker Cr-EDTA (a correction was made assuming an absorption in the rumen, small intestine and large intestine of 2, 0.5 and 0.5%, respectively; M. Brandt, unpublished observations, 1979) in the appropriate digesta samples (corrected for incomplete recovery in the faeces) and the 24 h intakes of the markers.

For the comparison of the AA composition of the protein in the diets and in duodenal digesta, the method of Guilloteau et al. (1986) was used. In this method the similarity between two AA profiles is expressed in the distance in chi^2:

$$X^2 = \sum_{k=1}^{17} (AA_{ik} - AA_{jk})^2 / ((AA_{ik} + AA_{jk}) / 2)$$

In this equation AA_{ik} and AA_{jk} are the respective percentages of AA k in total AA (TAA) of diet i and of duodenal digesta j.

Data were subjected to analysis of variance considering diet, animal and period as fixed effects. Diet effects were declared significant at $P<0.10$ unless otherwise indicated.

RESULTS

The daily intakes of DM and CP and the proportions of AA in TAA of the diets are given in Table 3. The DM intakes were similar for the two diets but cows receiving the SBM diet consumed less CP, resulting in different CP concentrations in total diet DM. The AA profiles of the diets reflected the differences observed for SBM and FM (Table 2).

Ruminal variables are shown in Table 4. Average ruminal NH_3-N concentrations were different between diets. At all time points, values were greater for the SBM diet than the FM diet and all differences were significant with the exception of the 0 and 5 h values. No clear postprandial peak of NH_3-N concentrations was observed for either diet. Ruminal pH values were higher for the FM diet than for the SBM diet and the differences were significant at 2 and 8 h postfeeding.

Daily intakes of OM and digestibility of OM in the stomachs, the small intestine and the large intestine were similar for both diets (Table 5), although numerical values indicate that the OM of the FM diet was more digestible in the small intestine than the OM of the SBM diet. Total tract digestibilities of OM were high for both diets and slightly but significantly greater for the SBM than for the FM diet.

Variables of N intake and digestion are presented in Table 6. As indicated by the NAN flow to the duodenum compared with N intake and by apparent digestibility of N in the stomachs, the NAN flow to the duodenum was almost identical to N intake for both diets. When daily NAN flow to the duodenum was related to OM apparently digested in the stomachs or in the total tract, higher values were observed for the FM diet. However, none of the differences were significant. The apparent digestibilities of N in the stomachs and total tract and the apparent digestibilities of NAN in the small intestine and large intestine were not different ($P>0.10$) between the two diets, although numerical values indicate that the FM diet had slightly higher digestibilities in the small intestine and in the total tract.

TABLE 3

Daily intakes of dry matter, crude protein and amino acids and crude protein content and amino acid composition of soyabean meal and fish meal diets fed to dairy cows

Ingredient	Diet	
	soyabean meal	fish meal
Dry matter, kg/day	12.6	13.2
Crude protein, g/day	2397	2825
Crude protein, g/kg dry matter	190	214
TAA[1], g/day	2293	2681
EAA[2], g/day	1033	1294
NEAA[3], g/day	1261	1388
EAA, g/100 g TAA intake	45.0	48.2
leucine	8.3	8.6
lysine	6.4	8.0
valine	5.3	5.9
arginine	7.3	6.4
threonine	4.3	4.9
isoleucine	4.4	4.6
phenylalanine	5.1	4.2
histidine	2.3	2.8
methionine	1.6	2.9
NEAA, g/100 g TAA intake	55.0	51.8
glutamic acid	16.8	13.5
aspartic acid	11.3	10.5
glycine	4.6	6.8
alanine	5.0	6.4
tyrosine	3.6	3.2
serine	4.9	5.1
proline	7.0	4.5
cystine	1.8	1.7

[1] total amino acids

[2] essential amino acids

[3] non-essential amino acids

TABLE 4

Ammonia-nitrogen (NH_3-N) concentrations and pH values in the ventral sac of the rumen of dairy cows fed a soyabean meal or fish meal diet

Item	Postfeeding h	Diet		SEM	P
		soyabean meal	fish meal		
NH_3-N, mmol/l	0	14.0	7.7	1.7	0.129
	1	15.4	7.5	1.1	0.036
	2	13.7	6.5	1.0	0.036
	3	10.9	4.8	0.7	0.028
	5	11.0	3.5	2.0	0.119
	8	7.6	2.3	1.1	0.081
pH	0	6.4	6.6	0.3	0.732
	1	6.2	6.5	0.2	0.512
	2	5.9	6.4	0.1	0.091
	3	5.9	6.1	0.1	0.257
	5	6.0	6.0	0.1	0.143
	8	6.0	6.4	0.1	0.030

[1] each value represents the average of eight observations (two observations per cow)

TABLE 5

Daily intake, duodenal flow and apparent digestibility of organic matter in the gastrointestinal tract of dairy cows fed a soyabean meal or fish meal diet

Item	Diet		SEM	P
	soyabean meal	fish meal		
Intake, kg/day	11.7	11.8		
Flow to duodenum, kg/day	6.0	6.5	1.1	0.800
Apparent digestibility, %				
stomachs	48.7	47.4	2.8	0.780
small intestine	44.3	51.7	2.2	0.138
large intestine	20.3	4.2	9.6	0.359
total tract	77.5	76.6	0.2	0.063

TABLE 6

Daily intakes, duodenal flow and apparent digestibilities of nitrogen (N) and non-ammonia-nitrogen (NAN) in the gastro-intestinal tract of dairy cows fed a soyabean meal or fish meal diet

Item	Diet		SEM	P
	soyabean meal	fish meal		
Intake, g/day	384	452		
Flow to duodenum,				
NAN, g/day	380	442	60	0.534
NAN, g/kg DOMT[1]	40	47	2	0.164
NAN, g/kg DOMST[2]	65	83	12	0.398
Apparent digestibility, %				
stomachs, N	−0.3	1.6	4.5	0.795
small intestine, NAN	65.9	69.7	1.4	0.195
large intestine, NAN	13.5	8.7	7.8	0.709
total tract, N	70.5	73.2	1.4	0.309

[1] organic matter apparently digested in the total tract

[2] organic matter apparently digested in the stomachs

Daily flows of AA to the duodenum and AA composition of duodenal digesta are given in Table 7. There was only a non-significant difference ($P > 0.10$) between diets for TAA, EAA and non-essential AA (NEAA) flows to the duodenum. The AA profile of duodenal digesta was different between diets for cystine and tended to differ for lysine ($P = 0.133$), threonine ($P = 0.155$), glutamic acid ($P = 0.138$) and tyrosine ($P = 0.168$), all of which were higher in duodenal digesta of cows fed the FM diet. The concentration of TAA-N in NAN at the duodenum was 8.7 percentage units higher ($P = 0.162$) for the FM diet than for the SBM diet.

The AA flows to the duodenum as a percentage of AA intake and the distance in X^2 between AA profiles of the diets and duodenal digesta are presented in Table 8. The duodenal flows of TAA, EAA and NEAA were lower than the respective intakes, i.e., a net disappearance of AA occurred in the stomachs. The values for TAA, EAA and NEAA were not different between diets ($P > 0.10$). Values for individual EAA ranged from 57% for arginine in the SBM diet to 109% for methionine in the same diet. Differences between diets for duodenal EAA flow as percentage of intake were significant for arginine and methionine. Methionine flow to the duodenum was higher than intake in the SBM diet, whereas it was lower than intake in the FM diet. Values of NEAA flow to the duodenum relative to intake ranged from 40% for proline to 141% for glycine in the SBM diet. Values for glycine and alanine were higher and those for serine were lower for the SBM diet than for the FM diet. The distance in X^2 between the

TABLE 7

Amino acid flow to the duodenum and amino acid composition of duodenal digesta of dairy cows fed a soyabean meal or fish meal diet

Item	Diet		SEM	P
	soyabean meal	fish meal		
TAA[1], g/day	1844	2408	399	0.442
EAA[2], g/ day	851	1126	188	0.316
NEAA[3], g/day	992	1283	211	0.610
TAA-N, g/100 g DNAN[4]	78	87	3	0.162
EAA, g/100 g TAA	46.2	46.8	0.2	0.188
leucine	8.0	7.8	0.7	0.232
lysine	6.8	7.5	0.6	0.133
valine	6.1	5.9	1.4	0.588
arginine	5.3	5.8	2.1	0.200
threonine	5.3	5.0	0.4	0.155
isoleucine	5.1	4.9	1.9	0.486
phenylalanine	4.8	4.5	2.2	0.291
histidine	2.9	2.9	0.5	1.000
methionine	2.1	2.5	1.3	0.232
NEAA, g/100 g TAA	53.8	53.2	0.2	0.188
glutamic acid	13.0	13.3	1.0	0.138
aspartic acid	11.3	11.0	1.6	0.220
glycine	8.1	8.2	3.2	0.961
alanine	6.7	6.7	1.8	0.668
tyrosine	4.6	4.2	1.5	0.168
serine	4.3	4.8	1.6	0.180
proline	3.5	3.3	2.5	0.523
cystine	2.1	1.7	0.4	0.011

[1] total amino acids
[2] essential amino acids
[3] non-essential amino acids
[4] daily non-amonia-nitrogen flow to the duodenum

AA profiles of the diets and duodenal digesta differed between diets for TAA, EAA and NEAA and all values were higher for the SBM diet.

The disappearance of AA from the small intestine (Table 9) tended to be higher in cows receiving the FM diet. The percentage disappearance of TAA, EAA and NEAA from the small intestine was 5.0, 6.3 and 3.8 percentage units higher for the FM diet than for the SBM diet. Significant differences between diets among EAA were determined for leucine and isoleucine and, among NEAA, for glutamic acid, alanine and serine. The lowest values of only 49.5 and 55.4% for the SBM and FM diets, respectively, were obtained for cystine. The

TABLE 8

Amino acid flow to the duodenum as percentage of amino acid intake[1] and the distance in X^2 between diets and duodenal digesta of dairy cows fed a soyabean meal or fish meal diet

Item	Diet		SEM	P
	soyabean meal	fish meal		
SEM P EAA[2]	82.2	83.6	5.1	0.868
leucine	77.2	77.9	4.7	0.925
lysine	85.3	81.7	4.3	0.606
valine	90.8	86.4	3.3	0.457
arginine	57.2	78.1	3.9	0.063
threonine	97.6	89.2	4.2	0.292
isoleucine	92.9	91.3	8.6	0.906
phenylalanine	75.5	90.2	9.4	0.385
histidine	97.2	88.4	3.8	0.245
methionine	108.7	73.9	8.4	0.099
NEAA[3]	78.5	88.7	5.2	0.299
glutamic acid	61.8	85.0	5.7	0.103
aspartic acid	80.6	89.9	6.8	0.423
glycine	141.2	103.4	4.4	0.026
alanine	107.7	91.4	2.4	0.039
tyrosine	104.1	111.8	5.2	0.408
serine	71.6	81.2	2.3	0.095
proline	40.2	63.6	7.1	0.146
cystine	97.5	84.8	6.6	0.310
TAA[4]	80.2	86.2	5.1	0.491
X^2				
EAA	1.57	0.62	0.16	0.030
NEAA	6.35	0.99	0.58	0.023
TAA	7.92	1.35	0.43	0.008

[1] percentages were calculated individually for each cow from the duodenal AA flow and the respective intake and then averaged. Thus, data presented in this table may deviate from values calculated on the basis of average duodenal AA flows (Table 7) and AA intakes (Table 3)

[2] essential amino acids

[3] non-essential amino acids

[4] total amino acids

disappearance values of methionine and histidine in the SBM diet also were low (54.5 and 57.6%, respectively). Although the respective values for the FM diet were 15 and 10 percentage units greater, these differences did not reach the level of significance ($P = 0.211$ and $P = 0.210$, respectively). For both diets, lysine and arginine were the AA that apparently disappeared to the greatest extent from the small intestine.

TABLE 9
Disappearance of amino acids from the small intestine (% of duodenal amino acid flow) of dairy cows fed a soyabean meal or fish meal diet

Item	Diet		SEM	P
	soyabean meal	fish meal		
EAA[1]	66.3	72.6	1.8	0.130
leucine	67.4	73.1	1.1	0.063
lysine	79.6	81.7	1.8	0.487
valine	68.4	72.1	2.1	0.340
arginine	80.0	84.2	1.4	0.157
threonine	63.8	70.3	1.6	0.106
isoleucine	67.3	71.4	0.7	0.061
phenylalanine	68.5	72.3	0.9	0.104
histidine	57.2	68.1	4.2	0.210
methionine	54.5	70.2	6.1	0.211
NEAA[2]	70.7	74.5	1.4	0.199
glutamic acid	68.0	73.0	1.2	0.099
aspartic acid	71.2	72.0	1.4	0.749
glycine	77.2	78.1	1.9	0.772
alanine	61.9	70.2	1.6	0.065
tyrosine	69.3	75.3	2.8	0.264
serine	73.6	64.6	1.8	0.075
proline	63.7	67.2	2.6	0.440
cystine	49.5	55.4	4.4	0.447
TAA[3]	68.7	73.6	1.6	0.160

[1] essential amino acids
[2] non-essential amino acids
[3] total amino acids

DISCUSSION

This study was aimed at feeding the same amounts of rumen-degradable protein and rumen-degradable OM with both diets in order to obtain identical amounts of ruminally synthesized microbial protein. Changes in duodenal AA flow should then be due to rumen-undegraded protein from either SBM or FM. Surprisingly, differences between diets in ruminal NH_3-N concentrations as an indicator of extent of ruminal proteolysis were large. Besides the slightly higher rumen-degradable CP content of the SBM diet, it appears that the SBM and FM sources of this study were more divergent in ruminal CP degradation characteristics than reported by Susmel et al. (1989), which have been used for calculation of diet composition for this trial. Our findings, however, confirm data from *in situ* studies reported recently by Petit (1992) and Martillotti et al. (1995) that

rumen-degradable CP content of SBM and FM can differ by more than 20 and 15 percentage units, respectively, at assumed ruminal solid outflow rates of 5%/h. Lack of a clear postprandial peak of NH_3-N concentrations for both diets points to a continuous release of NH_3 from both FM and SBM. The NH_3-N concentrations found for the SBM diet and those at 0, 1 and 2 h after feeding for the FM diet were higher than 3.6 mmol/l, a value which has been reported to be sufficient for maximal growth rates of fluid associated bacterial populations *in vitro* (Satter and Slyter, 1974). The values obtained for the FM diet at 5 and 8 h postfeeding, however, were lower than 3.6 mmol/l. Because particle-adherent bacteria can have higher N requirements than those of ruminal fluid (McAllan and Smith, 1983), a temporary shortage of NH_3-N in the rumen of cows fed the FM diets could have depressed ruminal fibre degradation. Ruminal digestibility of the OM including fibre components, however, was not different between diets.

Although feed intake was low and concentrates contributed no more than 60% to DM intake, ruminal pH values were low. The major concentrate ingredient was tapioca, which has been reported to contain about 80% starch and sugars with a high (> 75%) solubility (Tamminga et al., 1990). The observed trend for lower pH with the SBM diet may be related to rumen-degradable fibre carbohydrates of SBM (Mikled, 1986). The low ruminal fluid pH of both diets probably decreased cellulolytic activity of the bacteria and decreased fibre degradation of both diets. The optimal pH for cellulolytic activity of bacteria in the rumen is near 6.8 (Terry et al., 1969) and ruminal fibre degradation *in vitro* was almost completely inhibited at a pH of 6.0 (Stewart, 1977). The low pH could thus be responsible for the relatively low proportion (62%) of total tract OM digestion that occurred in the stomachs. Because OM digestibilities in the total tract were high, post-ruminal digestion of OM obviously compensated for the low OM digestibility in the stomachs.

For both diets, duodenal NAN flow equaled N intake. Based on the observations that supply of NH_3 to ruminal microbes throughout the day was closer to microbial requirements for the SBM diet than the FM diet, we suggest that microbial protein contribution to duodenal NAN flow was greater for the SBM diet. This suggestion is supported by data of Strache (1991), who used duodenal digesta from this trial and cytosine as a microbial marker and estimated that the percentage of microbial N of duodenal NAN flow was 5 percentage units higher for the SBM diet than for the FM diet ($P < 0.10$). Because microbial CP contains more non-AA-N than rumen-undegraded CP due to nucleic acid-N, the trend observed for a greater percentage of TAA-N in NAN at the duodenum of cows fed the FM diet supports this assumption. The greater amount of rumen-undegraded CP as observed for the FM diet will be advantageous for the dairy cow only when EAA and in particular those limiting milk yield are protected from rumen degradation to the same extent as CP and

when disappearance of CP from the small intestine is not decreased. The trend to greater disappearance of NAN from the small intestine of the FM diet indicates that this diet supplied more available NAN to the small intestine than the SBM diet.

With the exception of cystine, differences between diets for proportions of EAA, NEAA and individual AA in TAA of duodenal digesta could not be observed. When the AA profile of duodenal digesta was related to the profile of the diet (Table 8), however, the FM diet showed less variation. Changes in AA composition of duodenal digesta compared with the diet were expressed in X^2 values. Values around 1 for the FM diet and from 1.9 to almost 8 for the SBM diet indicated that these changes were small for the FM diet but considerable for the SBM diet. Likewise, Susmel et al. (1989) have suggested that *in situ* rumen exposure affected the biological value of FM less than that of vegetable foods. The effect of rumen fermentation on degradation of individual AA and on AA composition of rumen undegraded protein may vary. Tamminga (1979) reported that in dairy cows fed a range of diets methionine was degraded to a lesser extent than TAA. We found that the value of methionine in duodenal digesta as percentage of methionine intake was greater than the value of TAA for the SBM diet but lower for the FM diet. These observations indicate that methionine was less degradable than TAA in the SBM diet but more degradable than TAA in the FM diet. Variation of individual AA degradation due to diet and protein sources has also been reported by King et al. (1990) and Cozzi et al. (1995).

Different extents of postruminal AA disappearance should be accounted for when the true protein value of a feedstuffs is assessed. *In vivo* studies are inconsistent with respect to variation in the percentage disappearance of individual AA from the small intestine (Titgemeyer et al., 1989; Keery et al., 1993; Lebzien and Rohr, 1994). Lebzien and Rohr (1994) reported that, after correction for endogenous AA, values of AA disappearance from the small intestine did not differ between EAA and NEAA. We found that ranking of individual AA in respect of percentage disappearance from the small intestine was similar for both diets, whereas, the extent of disappearance differed largely within and between diets. The same observation has been reported for four different protein sources including SBM and FM by Titgemeyer et al. (1989). In contrast to data for EAA presented by Keery et al. (1993), the disappearance of individual AA from the small intestine was not in proportion to their concentration in the digesta flowing to the small intestine. The same authors (Keery et al., 1993) concluded that preferential absorption of NEAA occurred from the small intestine, although in their study, the EAA to NEAA ratio remained almost constant between the abomasal (0.82) and ileal (0.81) digesta. The EAA to NEAA ratios in duodenal and ileal digesta were 1.03 and 0.99 for the SBM diet and 1.04 and 0.96 for the FM diet, indicating preferential disappearan-

ce of EAA from the small intestine. The EAA to NEAA ratio of endogenous protein from bile and pancreatic secretions of dairy cows was 0.63 and 0.05, respectively (Hagemeister,1987, unpublished observations). Therefore, the true difference between EAA and NEAA in disappearance from the small intestine might even be larger than reported.

CONCLUSIONS

Replacing SBM by FM in diets for dairy cows can increase the amounts of ruminally undegraded CP and AA available for digestion in and absorption from the small intestine. Ruminal fermentation had a pronounced effect on AA composition of duodenal digesta. This indicates a selective ruminal release of individual AA. Percentage disappearance of individual AA in the small intestine differed within and between SBM and FM diets. Values for percentage disappearance of individual AA from the small intestine did not reflect composition of TAA of the diets or of duodenal digesta. It can be concluded that absorbed AA contents of feedstuffs must be determined individually by feedstuff and AA. The observed preferential disappearance of EAA compared with NEAA from the small intestine would increase available EAA contents for both diets.

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STRESZCZENIE

Ubytek aminokwasów w przewodzie pokarmowym krów otrzymujących dawki zawierające śrutę sojową lub mączkę rybną

Cztery krowy z przetokami do żwacza, dwunastnicy i jelita biodrowego żywiono dawkami zawierającymi taką samą ilość rozkładalnej w żwaczu substancji organicznej i białka ogólnego, w których głównym źródłem białka była śruta sojowa lub mączka rybna. Oznaczono ubytek substancji organicznej, azotu i aminokwasów (AA) w jelicie cienkim i grubym. Stwierdzono tendencję do większego ubytku tych składników z jelita cienkiego krów otrzymujących mączkę rybną. Porównując skład AA treści dwunastnicy i dawki wskazano, że podczas fermentacji w żwaczu profil AA mączki rybnej zostaje zmieniony w mniejszym stopniu niż śruty sojowej. Ubytek poszczególnych AA w jelicie cienkim różnił się w obrębie i pomiędzy dietami. Ubytek niezbędnych AA z jelita cienkiego był większy niż niezbędnych AA.

Stwierdzono, że wartość pokarmowa białka pasz, wyrażana jako wchłonięte AA, powinna być oznaczana oddzielnie dla paszy i poszczególnych AA.