AMINO ACID DIGESTIBILITY AS AFFECTED BY VARIOUS FIBER SOURCES AND LEVELS

1. DIFFERENCE BETWEEN ILEAL AND FECAL DIGESTIBILITY OF AMINO ACIDS

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Summary

A simple cross-over design was used in digestion experiment carried out on finishing pig (70 kg body wt.) fitted with ileal T-cannula, to determine the difference between ileal and fecal digestible values as affected by various fiber sources and levels. The series of semi-purified diets were formulated in an attempt to meet 1, 3, 7 and 9% crude fiber level, with alfalfa meal (AFM), rubber seed meal (RSM), leucaena meal (LM) and cellulose. Both the levels and sources influenced the amino acid digestibilities, as increasing crude fiber level the digestibilities increased. The digestibilities of amino acids at ileal level were higher than at fecal level. The magnitude of response were ranged from 1.76 to 8.41 percentage unit or 4.86 by average. The dry matter digestibilities of the diets reflect the digestibilities of amino acids as accumulation of fiber would increase endogenous losses. It indicates that the digestibilities of amino acids varied irregularly among diets, probably depended on a dietary nutrient and individual fiber fraction contents.

(Key Words: Dietary Fiber, Ileal Digestibility, Fecal Digestibility, Fiber Sources and Levels, Cannulated Pigs)

Introduction

The digestibility of nutrients consistently decreases with increasing fiber content in the diet and depends on the type and origin of fiber sources (Fernandez and Jorgensen, 1986). The chemical and physical characteristics of fiber may influence amino acid digestibility. The difference between feedstuffs and among samples of the same feedstuff, may result from difference in the level and composition of crude fiber (Sauer and Ozimek, 1986), depend on degree of lignification (Mitaru et al., 1984). Difference between the ileal and fecal digestibility coefficient may also depend on the amount of carbohydrate that reaches large intestine. This discrepancy of digestible amino acids that remained undigested in the small intestine do not necessarily appear in feces, but can be degraded during fermentation in the hindgut (Taverner and Farell, 1981b). This study was designed to determine the difference of amino acid digestibility as affected by various fiber sources and levels collected at different sites.

Materials and Methods

Diets

The series of experimental diets were composed of alfalfa meal, rubber seed meal, leucaena meal and cellulose. All fiber sources were ground in semi-power form and included in the diets at the level to meet 1, 3, 7 and 9% crude fiber. All diets, except cellulose series were added with isolated soy protein in an attempt to meet isonitrogenous. Corn oil and starch were added in various content to meet isocaloric. The formula and chemical composition are shown in table 1. Chromic oxide was added at 0.5% as digestible marker.

Design

Four barrows with an average body weight of

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TABLE 1. FORMULA AND CHEMICAL COMPOSITION OF THE DIETS USED IN THE EXPERIMENT (%)[1]

Ingredients	AFM-series				LM-series				RSM-series				PF-series			
CF level (%)	1	3	7	9	1	3	7	9	1	3	7	9	1	3	7	9
Ingredients																
Alfalfa meal	5.0	15.0	34.7	44.6	–	–	–	–	–	–	–	–	–	–	–	–
Leucaena meal	–	–		–	4.1	12.5	28.25	36.45	–	–	–	–	–	–		–
Rubber seed meal	–	–	–	–	–	–	–	–	3.6	10.8	25.1	32.3	–	–	–	–
Cellulose	–	–	–	–	–	–	–	–	–	–	–	–	1.15	3.35	7.8	10.0
ISP	13.1	10.9	6.6	4.45	13.45	12.1	9.3	7.9	13.1	10.85	6.45	4.25		–	–	–
Starch	72.35	62.2	45.3	35.7	72.35	63.25	48.95	40.45	73.3	65.9	54.55	47.85	89.1	83.9	77.45	73.25
Glucose	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Corn oil	–	3.0	5.0	7.0	–	3.0	5.0	7.0	–	3.0	5.0	7.0	-	3.0	5.0	7.0
Ca-carbonate	0.75	0.2	–	–	1.2	0.9	–	–	1.5	1.25	0.95	0.9	0.9	0.9	0.9	0.9
Monosodium-PO_4	1.2	1.0	1.3	1.65	1.65	1.6	1.0	1.8	1.6	1.3	1.3	1.2	1.15	1.15	1.15	1.15
Dicalcium-PO_4	1.2	1.3	0.7	0.2	2.85	0.25	1.1	–	0.7	0.5	0.25	0.1	1.3	1.3	1.3	1.3
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vit.-min premix[2]	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Chromic oxide	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Chemical analysis																
Crude protein	11.45	11.64	10.68	10.20	12.34	11.61	10.71	10.58	12.88	12.38	13.31	13.29	2.65	2.27	2.27	2.37
Ether extract	0.79	3.05	4.83	7.33	0.62	2.01	2.46	3.05	0.49	1.78	2.23	3.55	0.49	1.40	2.93	7.54
Crude fiber[3]	1.00	3.00	7.00	9.00	1.00	3.00	7.00	9.00	1.00	3.00	7.00	9.00	1.00	3.00	7.00	9.00
Ash	4.06	5.50	5.86	6.17	4.96	5.47	7.18	8.46	3.49	4.31	4.63	4.42	3.99	4.67	4.77	5.16
NFE	82.19	75.98	69.74	63.99	80.62	76.75	70.75	66.52	81.79	77.70	74.27	70.59	91.98	88.92	83.47	76.20
Calcium	1.34	1.45	1.47	1.52	1.62	1.52	1.90	2.11	1.79	2.24	2.04	2.27	1.58	1.53	1.83	1.87
Phosphorus	0.52	0.66	0.57	0.56	0.54	0.64	0.66	0.58	0.38	0.50	0.56	0.58	0.37	0.50	0.52	0.52
Energy (kcal/kg)[3]	3711	3668	3410	3312	3703	3668	3463	3382	3719	3724	3570	3529	3797	3815	3707	3889

[1] Abbreviated: AFM-series, alfalfa meal added to meet 1, 3, 7 and 9% crude fiber. RSM-series, rubber seed meal added to meet 1, 3, 7 and 9% crude fiber. LM-series, leucaena meal added to meet 1, 3, 7 and 9% crude fiber.

[2] Contributed the following nutrients/kg of diet: Zn, 100 mg; Cu, 10 mg; Mn, 20 mg; Fe, 150 mg; Se, 1 mg; Vitamin A, 4,000,000 IU; Vitamin D3, 800,000 IU; Vitamin E, 6,000 IU; pyridoxine, 800 mg; Cobalamine, 6,000 mg; Ca-pantothenate, 3,000 mg; niacin, 10,000 mg; folacin, 400 mg and ethoxyquin, 500 mg

[3] Calculated values.

70 kg and fitted with ileal T-cannula were used in the digestion trial of simple cross over design. They were raised in individual cage with raised slatted floor. Each trial period was 8 d long and separated by 3 d adjusted period. Each day's feed supply was given in to equal meal of 1000 g at 7.00 and 19.00, and was mixed with 2 liter of water to form a gruel. All pigs were provided with fresh water ad libitum. The ileal digesta collection procedure were similar to Jorgensen et al. (1984). They were collected for 12 hr on two days, started from 9:00 on d5 and from 7:00 on d6 by 2-hr interval and, repeated again on d8 and d9. After each 2 hr of collection the vinyl bag used to collect digesta were removed and frozen. Fecal collection was made from 7:00 of d3 to 19:00 of d4 of each period. The collections for individual animals in each period were pooled, dried in an air forced oven at 60°C for 36 hr and 72 hr for fecal and digesta samples, respectively. Then, all samples were ground through 1 mm screen by Wiley mill before representative samples were taken for analyses.

Chemical analyses

All samples were analyzed for proximate composition according to AOAC (1984) method. The fiber fractions, including NDF, ADF, lignin and cellulose were analyzed by Georing and Van Soest (1979) method. Fenton and Fenton (1979) procedure was used to determine the concentration of chromic oxide. Amino acid contents were analyzed using auto amino acid analyzer model KLB 4150 alpha. The calculation of amino acids digestibility was performed by Austreng (1978) method for apparent digestibility and for true digestibility by slightly changed equation introduced by Dabrowski and Dabrowska (1981). The digestibility values were analyzed and compared treatment mean by General Linear Model using SAS (1985) procedure.

Results and Discussion

Mean ileal and fecal digestibility values of the nutrients from added alfalfa meal, rubber seed meal and leucaena meal at the level of 1, 3, 7 and 9%, respectively, are shown in table 2 and table 3. From the ileal and fecal digestibility obtained, it was clear that at both levels, the digestibility values for dry matter, protein and amino acids decreased as the crude fiber level increased. In addition, the differences in the digestibility of nutrients within fiber source series were higher at ileal than at fecal level. The explanation for the first tendency was probably, that more nutrients are transferred to the caecum-colon and this results in greater microbial activity which also includes synthesis of amino acids and protein. Most of amino acids and the protein are excreted with the feces (Just et al., 1981; Sauer et al., 1982). However, in table 2 at 7% crude fiber level, the average amino acid digestibility was found to be lower than at 9% crude fiber level. Dierick et al. (1989) reported that it was important for decreasing in dry matter digestibility to reflect the accumulation of fiber in ileal digesta and feces. The explanation for present study could be applied to that literature since the value of dry matter

TABEL 2. MEAN ILEAL DIGESTIBILITY VALUES OF AMINO ACIDS AS AFFECTED BY THE DIFFERENT LEVELS OF CRUDE FIBER (%)

Components	Crude fiber level			
	1%	3%	7%	9%
Crude protein	96.04	94.7	90.62	84.77
Dry matter	94.46	90.08	79.12	80.42
Indispensable amino acids				
Arginine	97.83	95.53	91.30	86.90
Histidine	93.57	91.13	66.93	75.57
Isoleucine	94.47	92.67	82.23	89.03
Leucine	95.87	94.47	85.27	93.07
Lysine	96.43	95.37	86.20	89.33
Methionine	96.13	96.77	80.30	81.03
Phenylalanine	94.43	94.77	77.77	76.83
Threonine	93.27	93.23	79.97	87.67
Valine	93.53	90.77	83.80	87.73
Dispensable amino acids				
Alanine	95.53	96.23	84.53	78.33
Aspartic acid	93.63	92.80	79.20	80.57
Glutamic acid	97.37	96.57	88.27	91.23
Glycine	94.23	99.53	84.07	90.13
Proline	105.03	106.53	96.27	87.93
Serine	95.77	95.87	76.60	86.73
Tyrosine	100.87	95.93	83.77	88.17
Mean	96.12	95.50	82.90	85.64

digestibility was found to be low at 7% crude fiber level in comparison with 9% crude fiber level within series. The accumulation of fiber would increase the sloughish process of cell lining by mechanical erosion or by endogenous loss in various ways.

The second tendency was contrasted to Mitaru et al. (1984) and summary made by Sauer and Ozimek (1986) that amino acid digestibility coefficient obtained by the fecal analysis method were, for most amino acids in most feedstuff, higher than those obtained by the ileal analysis method. The explanation for the present finding, due to that fiber markedly depressed fecal amino acid digestibilities by increased bacterial fermentation activity in the hindgut, resulting in an increased nitrogen excretion with the feces. The fiber fractions have a propulsive effect on nutrients, shifting their digestion from the small intestine to the hindgut. This negative effect could be explained as follows. Firstly, the effect of fiber on transit time, provided less time for further process of digestion and absorption. Several studies reviewed by Dierick et al. (1989) had indeed revealed that high fiber diet with fibrous component, generally reduced the retention time for feed in the small intestine and increased overall passage time. Secondly, the water-binding capacity of fiber which reduced the rate of diffusion of the products of digestion towards the mucosal surfaces. Thirdly, the mechanical erosion. Finally, the adsorption of nutrients on the fiber (Bergner, 1984; Howard et al., 1986).

Difference between digestibility values for these diets might be derived from difference in the level and composition of crude fiber as proposed by Sauer and Ozimek (1986). Austic (1983) summerized results from the literature and calculated the average difference in apparent digestibilities of amino acids as determined by sampling ileal contents and feces. The average difference was 6.5 percentage units. In the present study (table 4), the difference was ranged from 1.76 to 8.41 percentage unit or 4.86 by average. It was hard to directly compare with data of Austic (1983) since these diets were calculated and concerned only with level of crude fiber. The difference varied among the crude fiber levels might be revealed from difference in the composition of fiber from various sources. The greater difference for feedstuff of low protein digestibility than of high protein digestibility was proposed by Sauer and Ozimek (1986). Their findings also confirmed the present results as the difference between ileal and fecal level simultaneously with changeable magnitude. All of the amino acids, threonine, glycine and proline disappeared to a large extent to the large intestine were well agreed with Taverner and Farell (1981b), those occuring much abundantly in mucin protein (Horowitz, 1967) and endogenous ileal digesta (Taverner et al., 1981a).

TABLE 3. MEAN FECAL DIGESTIBILITY VALUES OF AMINO ACIDS AS AFFECTED BY THE DIFFERENT LEVELS OF CRUDE FIBER (%)

Components	Crude fiber level			
	1%	3%	7%	9%
Crude protein	87.84	91.04	76.89	72.32
Dry matter	87.79	90.04	79.43	77.12
Indispensable amino acids				
Arginine	95.23	95.40	78.30	89.90
Histidine	87.67	89.53	76.60	57.87
Isoleucine	92.57	91.43	80.47	79.23
Leucine	92.20	92.10	83.40	82.77
Lysine	89.87	93.70	82.17	80.50
Methionine	90.00	91.03	78.50	72.80
Phenylalanine	92.50	90.73	84.67	61.50
Threonine	88.47	89.93	78.27	76.07
Valine	90.27	89.33	79.77	82.47
Dispensable amino acids				
Alanine	90.10	89.17	80.37	75.60
Aspartic acid	92.30	94.60	82.97	65.20
Glutamic acid	94.67	95.97	88.10	98.17
Glycine	87.07	90.67	77.07	76.17
Proline	81.50	95.00	79.27	80.53
Serine	91.70	93.27	72.30	79.20
Tyrosine	93.30	84.50	86.10	77.80
Mean	90.59	91.65	81.14	77.24

These tendencies revealed the fact that the digestibility values varied irregularly among diets, probably depended on a dietary nutrient and fiber fractions. Indeed, before reaching the fermentation site in the gut of the pigs, the caecum and large intestine, fiber through its physiochemical properties (water holding, cation-exchange,

TABLE 4. DIFFERENCE BETWEEN ILEAL AND FECAL DIGESTIBILITY VALUES OF AMINO ACID AS AFFECTED BY THE DIFFERENT LEVELS OF CRUDE FIBER (%)

Components (%)	Crude fiber level			
	1%	3%	7%	9%
Crude protein	8.70	3.73	13.73	12.45
Dry matter	6.97	0.04	-0.31	3.30
Indispensable amino acids				
Arginine	2.60	-0.07	13.00	-3.00
Histidine	5.60	1.60	-9.67	17.70
Isoleucine	1.90	1.23	1.77	9.80
Leucine	3.67	2.37	1.87	10.30
Lysine	6.57	1.67	4.03	8.83
Methionine	6.13	5.73	1.80	8.23
Phenylalanine	1.93	4.03	-6.90	15.33
Threonine	4.80	3.30	1.70	11.60
Valine	3.27	1.43	4.03	5.27
Dispensable amino acids				
Alanine	3.53	3.63	-1.17	4.97
Aspartic acid	3.23	1.63	1.57	13.13
Glutamic acid	2.70	0.60	0.17	6.93
Glycine	7.17	8.87	7.00	13.97
Proline	23.53	11.53	17.00	7.40
Serine	4.07	2.60	-5.70	7.53
Tyrosine	7.57	11.43	-2.33	10.37
Mean	5.54	3.85	1.76	8.41

adsorption and gel-forming properties) exert diverse physiological actions along the gastro-intestinal tract.

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