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Amino Acids in Rumen Escape Protein

1. Forages and Plant Source By-Products

P.H. Robinson

Cooperative Extension Specialist

University of California, Davis, CA 95616-8521

Dairy cattle require dietary nitrogen and proteins to meet the requirements of their ruminal populations of microorganisms. If ruminal microorganisms, particularly bacteria, become nitrogen deficient then their growth and fermentative activity can be restricted leading to reduced digestion of structural carbohydrates and declining levels of feed intake. These microorganisms, which die and wash out of the rumen to the small intestine, provide a substantial proportion of the protein absorbed from the small intestine of the animal to meet the animal's metabolic requirements for amino acids, which are the building blocks of proteins. However, with the exception of the lowest producing dairy cows, the microbial contribution alone is seldom sufficient to meet these metabolic requirements making enhancement of intestinally delivered supplies of protein from dietary feed sources critical if the animal is to reach its genetic potential for productivity.

Forages and plant source by-products comprise the base of most successful rations for lactating dairy cows. These feedstuffs typically contribute structural fiber, protein, minerals and variable quantities of non-structural carbohydrates that are available to be fermented by microbes in the rumen. However forages containing between 15 and 22% crude protein, of which 20 to 30% escapes the rumen undegraded, that is fed at 35% of total dry matter intake to high producing dairy cows will also supply between 250 and 550 g of intestinally absorbable amino acids. These quantities represent between 10 and 20% of the animals' total intestinal amino acid requirement. Thus it is important to accurately estimate the amino acid composition of these rumen escape proteins if the amino acid requirements of the animals are to be met, but not exceeded.

Purpose

The amino acid profile of the rumen escape protein of a number of feedstuffs commonly fed to dairy cows was determined over a period of several years as the feedstuffs were collected from various commercial sources. This article presents the amino acid profile of several forages and plant source by-products. Subsequent articles present similar data for grains and whole seeds, as well as plant and non-plant source protein meals.

Methods Used

Samples of several forages and plant source by-products were collected from various sources. The amino acid composition of the rumen escape protein of these feedstuffs was estimated using a traditional rumen in situ method. Using this procedure, small quantities of various forages and plant source by-products were incubated in small nylon bags in the rumens of two dry cows fed a diet of grass hay and minerals at a maintenance level of energy intake. The undigested feedstuff residues, that were removed from the rumen at predetermined times, were dried and assayed for amino acids utilizing traditional amino acid assay procedures, with a separate analysis for cystine and methionine that included oxidation with performic acid. Times of rumen incubation of all forages, except alfalfa and timothy pasture, were 24 h (rumen rate of passage (kp) estimated to be 4.17 %/h), whereas those for all plant source by-products and the two pasture forages were 16 h (kp estimated to be 6.25 %/h). No corrections were made for truly indigestible amino acids in the feedstuff residues or microbial amino acids in the feedstuff residues. This may influence interpretation of the data.

Results Available

The amino acid profiles of the undigested forage and plant source protein residues are shown in the Tables. Each of the feedstuff samples represents a different source of that particular feedstuff. There is substantial variation in the amino acid profile of the protein residues among feedstuffs, with differing extents of variation within a feedstuff among amino acids.

Use of the Data

The data presented in the tables can be utilized in preparing, or evaluating, rations for dairy cattle under situations where the requirements of the animals for intestinally absorbable amino acids have been estimated. The amino acid values in the tables can be directly applied to the estimated rumen escaping digestible crude protein.

Future Perspectives

This project is ongoing. The author plans to update this article on an annual basis to reflect new sample analyses that have become available during that period of time.

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P.H. Robinson is a Cooperative Extension Specialist responsible for dairy cattle nutrition and nutritional management. He can be reached at: (530) 754-7565(voice) or (530) 752-0172(fax) or phrobinson@ucdavis.edu(office) or lovenbu@pacbell.net(home).

Table 1. Amino Acids in Rumen Escape Protein of Forages (% CP)

Feedstuff	#		Lys	His	Arg	Thr	Gly	Val	Ile	Leu	Tyr	Phe	Cys	Met
Alfalfa hay	2	Min	4.14	1.44	3.31	4.21	5.54	4.09	3.25	6.98	2.37	4.73	1.69	2.17
		Max	4.33	1.66	3.97	4.50	5.92	4.38	3.55	7.34	2.37	5.66	2.01	2.49
		Avg	4.24	1.55	3.64	4.36	5.73	4.24	3.40	7.16	2.51	5.20	1.85	2.33
Alfalfa pasture	2	Min	3.92	1.51	3.57	3.63	5.31	3.99	2.75	7.05	2.39	5.05	1.59	2.87
		Max	4.25	1.83	3.90	4.35	7.71	4.27	3.05	7.09	2.70	5.05	1.83	3.19
		Avg	4.08	1.67	3.73	3.99	6.51	4.13	2.90	7.07	2.55	5.05	1.71	3.03
Alfalfa silage	2	Min	3.52	1.76	2.40	3.68	4.95	3.67	2.56	5.60	2.24	4.16	1.92	1.76
		Max	3.67	1.92	2.55	3.83	5.28	4.16	2.71	7.03	2.55	4.63	2.55	2.72
		Avg	3.60	1.84	2.48	3.76	5.12	3.92	2.64	6.31	2.40	4.40	2.24	2.24
Barley silage	2	Min	3.08	1.34	2.67	3.34	4.34	3.45	2.34	5.34	2.34	4.17	2.00	2.67
		Max	3.17	1.45	4.54	3.45	4.35	3.45	2.54	5.80	2.90	4.18	2.72	3.08
		Avg	3.13	1.39	3.60	3.39	4.35	3.81	2.44	5.57	2.62	4.18	2.36	2.88
Corn silage	2	Min	2.46	1.33	3.22	2.46	4.88	2.46	2.08	4.54	2.35	4.17	2.08	3.07
		Max	3.43	1.63	3.25	3.61	4.92	3.25	2.53	6.86	3.03	4.70	2.53	3.22
		Avg	2.95	1.48	3.23	3.04	4.90	2.86	2.31	5.70	2.69	4.43	2.31	3.14
Corn/Sunflower silage	2	Min	3.15	1.18	2.21	3.31	4.42	2.84	2.36	5.52	2.21	3.63	2.06	2.51
		Max	3.39	1.73	2.68	3.54	4.73	3.24	2.68	6.93	2.51	4.13	2.21	3.31
		Avg	3.27	1.46	2.45	3.42	4.58	3.04	2.52	6.22	2.36	3.88	2.14	2.91
Oat silage	2	Min	3.94	1.35	3.20	3.20	4.22	2.95	2.22	4.92	2.46	3.88	2.53	2.53
		Max	4.05	1.48	3.21	3.71	4.68	3.21	2.70	5.40	2.53	3.94	2.95	2.71
		Avg	3.99	1.41	3.21	3.46	4.45	3.08	2.46	5.16	2.50	3.91	2.74	2.62
Timothy hay	2	Min	2.90	1.52	3.04	3.01	4.70	3.66	1.70	5.63	2.88	4.56	1.80	2.22
		Max	3.79	1.83	4.84	3.32	6.15	5.25	2.35	6.91	3.60	5.36	2.09	2.35
		Avg	3.35	1.68	3.94	3.16	5.43	4.46	2.03	6.27	3.24	4.96	1.95	2.29
Timothy pasture	2	Min	3.79	1.52	3.29	4.12	4.93	3.92	3.16	6.83	2.02	4.63	2.02	1.80
		Max	3.86	1.67	3.29	4.17	5.02	4.76	4.12	7.59	2.57	5.44	2.32	2.15
		Avg	3.83	1.59	4.15	4.14	4.97	4.34	3.64	7.21	2.30	5.03	2.17	1.98
Timothy silage	2	Min	2.71	1.18	2.71	1.74	4.06	2.90	2.13	5.22	2.32	4.45	1.74	2.52
		Max	3.87	1.55	3.03	2.19	4.72	3.75	3.37	6.40	2.36	4.55	1.85	2.69
		Avg	3.29	1.36	2.87	1.97	4.39	3.34	2.75	5.81	2.34	4.50	1.80	2.60

Table 2. Amino Acids in Rumen Escape Protein of Plant Source By-Products (% CP)

Feedstuff	#		Lys	His	Arg	Thr	Gly	Val	Ile	Leu	Tyr	Phe	Cys	Met
Beet pulp (dried)	2	Min	3.72	2.56	3.13	4.12	4.45	4.63	2.47	5.94	3.96	3.71	1.32	1.57
		Max	3.96	2.73	3.22	4.46	4.79	4.78	2.73	6.12	4.05	3.97	1.48	1.74
		Avg	3.84	2.64	3.18	4.29	4.62	4.71	2.60	6.03	4.00	3.84	1.40	1.65
Brewers' grains (dried)	2	Min	1.46	1.17	2.10	1.98	2.33	2.28	1.46	6.19	2.28	3.38	1.69	1.34
		Max	1.89	1.82	3.10	2.83	3.64	3.50	2.43	8.90	2.83	5.19	2.36	2.16
		Avg	1.67	1.49	2.60	2.41	2.99	2.89	1.94	7.54	2.55	4.29	2.03	1.75
Distillers' grains (dried, corn)	4	Min	1.79	1.99	3.05	5.57	3.03	3.00	2.18	11.04	3.17	4.70	2.08	2.28
		Max	2.17	2.43	3.53	6.34	3.73	4.20	3.17	11.47	3.60	5.33	2.30	2.62
		Avg	1.92	2.19	3.21	6.07	3.51	3.64	2.69	11.27	3.37	5.00	2.19	2.46
Distillers grains (dried, wheat)	2	Min	1.26	1.88	3.19	2.48	3.26	3.19	2.52	6.50	2.60	4.38	2.24	1.82
		Max	1.38	1.96	3.44	2.64	3.39	3.41	2.88	6.73	2.69	4.62	2.32	1.93
		Avg	1.32	1.92	3.31	2.56	3.33	3.30	2.70	6.61	2.64	4.50	2.28	1.87
Potato meal (dried)	2	Min	3.25	1.46	2.92	3.19	3.45	3.98	2.06	6.11	3.05	3.78	1.39	1.33
		Max	4.62	1.98	4.21	4.21	4.95	4.78	3.05	7.84	3.71	5.03	1.65	1.48
		Avg	3.94	1.72	3.56	3.70	4.20	4.38	2.55	6.97	3.38	4.41	1.52	1.41
Wheat bran	2	Min	4.07	1.36	4.72	4.20	6.78	6.56	2.44	6.24	2.62	3.80	4.88	3.15
		Max	4.46	1.84	6.51	5.15	6.78	7.86	3.41	8.13	2.71	3.93	4.98	3.53
		Avg	4.26	1.60	5.61	4.67	6.93	7.21	2.93	7.18	2.67	3.87	4.93	3.34
Wheat midds	2	Min	2.97	2.10	5.90	3.57	5.00	4.52	2.86	7.43	2.86	4.82	2.20	1.84
		Max	4.85	2.20	6.01	4.46	6.69	5.51	3.54	8.66	3.67	4.98	2.62	1.84
		Avg	3.91	2.15	5.95	4.01	5.84	5.01	3.20	8.05	3.26	4.90	2.41	1.84
Wheat shorts	2	Min	4.06	3.20	4.36	4.06	7.27	6.11	2.91	7.58	2.98	4.33	3.52	2.91
		Max	4.07	3.52	7.58	4.07	7.31	7.04	3.25	8.44	3.20	5.82	4.36	2.98
		Avg	4.07	3.36	5.97	4.07	7.29	6.57	3.08	8.01	3.09	5.07	3.94	2.94