AMINO ACID COMPOSITION OF THE CONTENTS IN VARIOUS SEGMENTS OF THE GASTROINTESTINAL TRACT OF MOOSE

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ABSTRACT: Concentrations of amino acids in various sections of the digestive tract of moose were investigated in 3 animals sampled in autumn. The concentration of amino acids in rumen contents were 1.5 to 2–fold higher when animals consumed a diet of deciduous twigs. The digesta from the small intestine, mainly from the first third of its length, had the highest concentration of amino acids per unit of dry weight. Amino acid levels continuously decreased along the length of the small intestine suggesting a transfer of amino acids across the intestinal wall. In the large intestine, slightly higher concentrations of amino acids were observed in the colon, more than likely due to the metabolic activity of microorganisms.

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Key words: amino acids, gastrointestinal tract, metabolic activity, moose, nutrient absorption

Moose have adapted to consume diets consisting of various forage plants in the process of ecological niche specialization (Stringham 1974, Cederlund 1987). As is the case in other wild ruminants, the moose diet varies seasonally, yet moose demonstrate a preference for deciduous and coniferous twigs even with an abundance of other forage plants available.

Most moose browse intake is degraded into volatile fatty acids, amino acids, ammonia, and other intermediate metabolites as a result of microbial digestion in the forestomach of the rumen. Part of the dietary protein is also degraded by microbes in the rumen, with subsequent synthesis of microbial protein. The remaining dietary protein that has escaped microbial digestion flows into the abomasum and then the small intestine or to the post–ruminal tract without change.

The intensity of the metabolic processes in the forestomach is a significant factor in the control of protein metabolism of ruminants. Microbial synthesis is a major source of protein in the rumen, and the total quantity of microbial protein (bacterial and protozoan) varies significantly depending on habitat and climatic conditions (Aliev et al. 1981).

The objective of this study was to determine the concentrations of amino acids in the rumen and other segments of the digestive tract of moose.

MATERIALS AND METHODS

Three moose were killed in autumn (October) and samples were obtained of the digestive contents of various segments of the alimentary canal. Samples were dried at 105°C to a constant weight to determine dry matter weight. Dried samples were analyzed for nitrogen by the Kjeldahl method. Samples were also exposed to acid hydrolysis and amino acid concentrations were determined by an automatic amino acid analyzer (T–339M, CSSR).

RESULTS AND DISCUSSION

Intestinal digesta of moose are heterogeneous mixtures containing large pieces of

twigs (>2.5 cm), whole leaves, and very small pieces of chewed food. The moisture content of the various intestinal tract samples fluctuated from 86 to 93% and was dependent on the type of diet consumed. The nitrogen intake from both dietary protein and nonprotein sources (including amino acid concentrations) varies significantly in moose by season. In spring, the branches of woody plants have the highest level of crude protein, which decreases during the summer due to the accumulation of structural compounds. In autumn, the concentration of crude protein and amino acids in deciduous twigs are 2 – 3 times lower than in spring samples (Badlo and Simakov 1990).

Concentrations of nitrogen and amino acids in dietary and intestinal digesta dry matter in autumn show that most amino acids in intestinal digesta are higher than in the diet (Table 1). Such autumn intestinal digesta levels demonstrate the transformation of dietary protein by microbes, although not as elevated as would be expected with summer diets. Thus, protein and amino acid content in intestinal digesta of moose is dependent on the nutritional status of the animal, with more than likely a great part of the dietary protein being transformed by microbes.

Rumen and reticulum ingesta are transported through the reticulo–omasal orifice and strained (as if through a "screen"), allowing the passage of small particles of

Table 1. Concentration of amino acids (g/kg dry matter) in the diet and digesta of moose forestomach.

Amino acids	Dietary Ration	Forestomach		
		Rumen	Omasum	Abomasum
Aspartic acid	6.20	14.50	9.90	10.63
Treonine	2.51	5.68	3.96	4.66
Serine	2.91	5.19	4.20	4.86
Glutamic acid	6.07	13.78	10.11	11.47
Proline	2.33	4.57	3.13	4.36
Cystine	–	0.14	0.02	0.05
Glycine	3.17	5.43	4.13	5.19
Alanine	3.22	6.89	4.90	5.86
Valine	3.01	6.22	4.34	5.23
Methionine	0.06	0.57	0.20	0.41
Isoluecine	0.05	0.57	0.20	0.41
Isoleucine	2.48	5.81	4.48	4.49
Leucine	4.66	8.42	6.17	7.43
Tyrosine	1.72	3.45	2.07	2.70
Phenylalanine	2.53	5.27	3.48	3.26
Lysine	3.09	7.08	4.36	6.29
Histidine	1.15	1.45	1.13	1.66
Arginine	2.26	3.49	2.92	3.92
Total	47.36	97.94	69.50	82.47
Crude protein	75.00	113.12	82.50	111.87

food along with the soluble nutrients in ruminal fluids. Larger particles of food that pass through the reticulo–omasal orifice are retained between the omasum's folds, with fluid components being transported comparatively rapidly to the abomasum. Omasum–retained materials have a higher percentage of dry matter (24.7%) but a lower concentration of nitrogen than ruminal fluids.

The fluid component of samples from the abomasum is greater than in the samples from rumen and reticulum, due to "abomasum juice" secretion. The concentration of nitrogen compounds closely resembles the concentrations of amino acids in the rumen digesta. However, nonprotein nitrogen levels were higher, probably as a result of the partial hydrolysis of some proteins, and also urea that has passed into the rumen directly through the rumen wall from the circulating blood.

The digesta flowing into the small intestine is characterized by its high proportion of fluid containing small particles of food and soluble nutrients. Secretions from the main digestive glands (pancreatic juice and bile, which are continuously secreted) cause the digesta sample to have a higher concentration of total dry matter nitrogen (6.5%).

Nonprotein nitrogen is increased (60%) as a result of the proteolytic activity of intestinal juices and digestive tract enzymes. The concentration of amino acids is 9–10 times higher in the digesta dry matter of the small intestine than in the diet sample (Table 2). Glutamic acid, proline, and glycine are markedly higher in the small intestine

Table 2. Concentration of amino acids (g/kg dry matter) in digesta from various segments of moose intestine.

	Small				Large		
Amino acids	4 m	7 m	13 m	20 m	Ceacum	Colon	Feces
Aspartic acid	26.94	22.81	12.20	11.41	6.78	7.65	6.21
Treonine	26.63	17.10	9.85	4.99	2.69	3.36	2.90
Serine	12.61	10.39	3.89	3.96	2.80	3.40	3.04
Glutamic acid	66.24	46.12	30.40	18.62	6.30	7.47	6.01
Proline	23.16	17.08	11.49	7.78	2.35	2.70	2.20
Cystine	0.94	1.27	0.72	0.25	–	–	–
Glycine	37.24	26.86	21.10	7.85	2.97	3.39	2.95
Alanine	28.77	18.16	13.10	8.09	3.52	3.71	3.61
Valine	26.26	19.84	14.00	9.01	2.57	3.75	2.63
Methionine	6.97	2.04	0.54	0.30	0.14	0.36	0.37
Isoleucine	19.35	18.06	12.54	6.36	2.02	3.01	2.10
Leucine	31.56	27.36	19.53	10.55	3.82	5.03	3.63
Tyrosine	15.04	12.34	6.44	3.55	0.97	0.88	1.78
Phenylalanine	24.10	15.64	8.28	5.23	2.40	2.61	2.61
Lysine	21.56	12.07	10.49	6.77	2.15	3.39	2.80
Histidine	8.41	5.08	2.76	1.71	0.66	0.95	0.84
Arginine	19.46	13.68	11.65	3.69	1.48	2.25	1.60
Total	392.24	285.90	188.98	82.20	43.62	53.91	45.28
Crude protein	407.50	317.50	205.60	111.25	69.37	78.75	84.37

samples. This may be due in part to the fact that, as has been observed by others for reindeer and sheep, glycine is secreted in the bile. In addition, there is evidence that glycine from plasma proteins may also be transferred through the intestinal wall of domestic ruminants.

It is well documented that the small intestine is the main site of nutrient absorption to the blood stream. The concentrations of amino acids in small intestine digesta, determined at distances of 4, 7, 13, and 20 m from the pylorus, continuously decrease with passage along the small intestine, with the greatest absorption occurring in the first half of the small intestine. The digesta from the large intestine has dry matter contents and amino acid levels similar to that of consumed food. This is shown particularly in the concentrations of amino acids in the digesta dry matter of the caecum. In the hindgut, fermentation processes continue due to the enzymes of microorganisms inhabiting it. The fermentation intensity depends on the presence of appropriate substrata in the digesta flowing to the large intestine. In the digesta samples furthest along in the large intestines, degradation processes dominate. Trends of increased concentrations in some amino acids indicate the presence of microbial protein synthesis in the colon.

Thus, the release of amino acids from dietary protein by digestion in moose is enriched as a result of the activity of ruminal microorganisms and protozoa. Simultaneously, the proportion of nonprotein nitrogen is likewise higher. The concentration of amino acids is 9–10 times higher in dry matter of small intestine digesta than in the daily dietary ration. This elevation may indicate an additional impact on dietary protein from the protein–enzymes of digestive juices, which after a loss of activity are denatured and degraded to amino acids. The continuous decrease in the concentration of amino acids in digesta as it flows to the distal end of the small intestine indicates an absorption process. No significant changes in the concentration of amino acids in hindgut digesta were observed when compared to amino acid values of digesta from the distal end of the small intestine. We observed no other changes in concentration of amino acids in dry matter of hindgut digesta.

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