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The amino acid composition of rumen-undegradable protein: A comparison between forages

B. Edmunds,*[1] K.-H. Südekum,*[2] R. Bennett,† A. Schröder,‡ H. Spiekers,§ and F. J. Schwarz#
*Institute of Animal Science, University of Bonn, 53115 Bonn, Germany
†Adisseo Europe-Africa-Middle East, 92160 Antony, France
‡Kemin AgriFoods Europe, 2200 Herentals, Belgium
§Institute for Animal Nutrition and Feed Management, Bavarian State Research Centre for Agriculture (LfL), 85586 Poing, Germany
#Animal Nutrition Weihenstephan, Technical University of Munich, 85350 Freising, Germany

ABSTRACT

The objective of this study was to improve knowledge regarding the amino acid profile of the insoluble portion of ingested forage escaping rumen degradation. Six forage categories were analyzed. Categories varied in botanical composition and each contained 2 samples. Samples within categories were derived from the same parent material but differed in harvest, maturity, or conservation type. The rumen-undegradable protein of all forages was measured by incubation for 16 h in the rumen of 3 nonlactating cows. All residues were corrected for microbial colonization. The AA profile of the residue was different to the original profile. Degradation trends of individual AA, in terms of increase or decrease relative to the original concentration, were similar between all forages. The AA profiles of forage residues, both within and between categories, were more similar to each other than to their respective original profile. This information may aid in improving the accuracy of estimating postruminal AA supply from forages while decreasing the number of samples required to be analyzed.
Key words: ryegrass, white clover, alfalfa, lysine

INTRODUCTION

Milk protein yield in high-producing dairy cows is often restricted by the first limiting AA (Rogers et al., 1984; Rulquin et al., 1993). In forage-based diets in particular, the majority of the AA requirements are met through the supply of absorbable AA provided by CP of microbial origin, which is relatively stable in its AA composition. However, as feed intake increases, the proportion of nonmicrobial AA reaching the duodenum increases in quantity (Merchen et al., 1986) and importance. Nonmicrobial AA is delivered through endogenous secretions and from proteins, peptides, and free AA of feed origin escaping rumen degradation. This rumen-escaped CP (RUP) may be transported solubilized in the liquid phase or as insoluble particles. The latter is the subject of focus in this study.

Some protein evaluation systems, such as the Dutch (DVE/OEB 2010: Van Duinkerken et al., 2011) and Nordic (NorFor; Volden and Larsen, 2011), assume that the AA composition of RUP is the same as that in the original feedstuff. Although results have been contradictory, it has generally been well proven that the AA profile of feed changes during rumen exposure (Erasmus et al., 1994; van Straalen et al., 1997; Von Keyserlingk et al., 1998). However, to what extent the profile is affected remains an open question and the difficulty of accurate measurement of RUP-AA has maintained use of the original AA profile to estimate duodenal supply. Additionally, the composition of AA from RUP varies depending on its source, meaning that the supply of intestinally absorbable AA can be manipulated by changing the quality of RUP (Seymour et al., 1990). Although the quantity of RUP is also important, an increase will not necessarily translate into improved lactational performance (Santos et al., 1998) if its quality does not meet the requirements of the first limiting AA. Knowledge of the AA profile of RUP is, therefore, essential for accurate diet formulation and precision feeding.

Concentrates usually supply the greater portion of feed AA to the duodenum of high-producing dairy cows. Forages are therefore generally overlooked, although their contribution to AA supply is not insignificant. The main problem lies in the measurement of changes occurring after rumen exposure, which is complicated and laborious. Two previous studies have indicated that after rumen exposure, the AA composition of grass silage was not remarkably different from that of unensiled grass (González et al., 2009; Edmunds et al., 2013). The idea that either unconserved or ensiled grass

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[1]Current address: Department of Agriculture and Food, Western Australia, PO Box 1231, Bunbury WA 6231, Australia.
[2]Corresponding author: ksue@itw.uni-bonn.de

Table 1. Description of samples and their corresponding N components, including CP, NDIN, ADIN, effective rumen-undegradable CP at a passage rate of 2%/h (RUP), and AA-N

Category	Feedstuff	CP (g/kg of DM)	NDIN (g/kg of CP)	ADIN (g/kg of CP)	RUP (g/kg of CP)	AA-N (g/kg of CP)
ALF	Alfalfa, fresh	191	68	46	113	724
	Alfalfa, dried	178	248	58	191	704
MG1	Meadow grass 1, fresh	140	70	33	148	737
	Meadow grass 1, hay	128	261	27	182	783
MG2	Meadow grass 2, fresh	189	232	16	107	717
	Meadow grass 2, dried	192	315	31	143	761
RG	Perennial ryegrass, first harvest	109	169	19	144	721
	Perennial ryegrass, third harvest	148	155	16	148	736
GC	Ryegrass/white clover, early	163	148	19	124	737
	Ryegrass/white clover, mid	148	91	21	102	724
WC	White clover, first harvest	241	21	28	115	783
	White clover, third harvest	276	40	27	131	786

may be used to predict the AA composition of RUP from the same or similar parent material is attractive, as it lowers the number of analyses required. Givens and Rulquin (2004) reported that AA profiles of hay and dehydrated forages are similar to those of fresh forages, with 49% of variability in forage AA profiles coming from the ensiling process. Based on this and previously stated similarities in the AA profile of RUP between unconserved and ensiled forage, one would also expect similarity between RUP-AA profiles of unconserved and dried forages. The next-highest influencing factor stated by Givens and Rulquin (2004) was forage species. The current study investigated whether this variation (i.e., conservation type and species) also extends to RUP. The results also serve to increase the data bank of AA profiles for RUP of forages.

MATERIALS AND METHODS

Forages

From Bavaria, Germany, 12 forages from the 2008 harvest were evaluated for AA before and following rumen incubation using an in situ technique. Six forage categories were used, each containing 2 samples (Table 1). The categories were perennial ryegrass (**RG**), white clover (**WC**), a ryegrass/white clover sown sward (**GC**), alfalfa (**ALF**), and meadow grass from 2 different fields (**MG1** and **MG2**). The 2 samples within each category came from the same parent material and differences are based on either harvest (RG and WC: first vs. third harvest), maturity (GC: early vs. mid bud), or conservation type (MG1: fresh vs. hay; ALF and MG2: fresh vs. artificially dried). A full description of these samples is presented in Edmunds et al. (2012; note: in that publication, 2 ALF and MG2 samples, each for both fresh and artificially dried material, are described; the ALF samples analyzed in the current study are from the third harvest; the MG2 samples only differ in the time spent wilting on the field and the AA profile of both samples from fresh and artificially dried MG2 were almost identical, except for a higher level of Pro in the longer-wilted sample; thus, the profiles were averaged for the current study). All samples and in situ residues were freeze dried. Original material was milled through a 3-mm screen for the in situ trial and through a 1-mm screen for all other analyses. Although the use of fresh material for in situ incubation is desirable, circumstances and equipment prevented this from occurring. Procedures used for the chemical analysis are described in Edmunds et al. (2012).

In Situ Procedure

A detailed description of the in situ procedure followed was reported by Edmunds et al. (2012). The procedure followed basic guidelines of Madsen and Hvelplund (1994) and used 3 nonlactating German Holstein cows, fitted with rumen cannula. Four bags per feedstuff per cow were incubated for 16 h on the basis that (1) all rumen-soluble material was assumed to have been solubilized, (2) sufficient material remained after rumen incubation for subsequent analysis, and (3) most other published work from various authors have used this time point. Cows received a diet of (DM basis) approximately and proportionately 0.22 soybean meal and mineral concentrate (approximately 4:1 soybean meal:mineral mix), 0.52 corn silage (CP and NDF: 75.5 and 461 g/kg of DM, respectively), and 0.26 grass hay (CP and NDF: 137 and 586 g/kg of DM, respectively) daily at 0700 and 1600 h, in 2 equal meals, meeting maintenance ME requirements. The bags were inserted into the ventral rumen directly before the morning feed and were immediately immersed in ice water upon removal. All bags underwent machine washing in cold water and were subsequently freeze dried. Loss of small