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Digestibility and nitrogen retention in llamas and goats fed alfalfa, C_3 grass, and C_4 grass hays

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Abstract

The objective of this experiment was to determine the relative digestive capabilities and N retention between goats and llamas fed three forages. Four llamas (2 yrs; 125 ± 7.3 kg BW) and four Boer-cross goats (2 yrs; 53 ± 8.4 kg BW) were housed in metabolism crates and fed alfalfa (*Medicago sativa*; ALF), temperate C_3 grass (*Festuca arundinacea*; C3G) and tropical C_4 grass (*Cynodon dactylon*; C4G) hays. Each forage was fed for 21 d during which time the animals were adapted to the forage, followed by a 5 d period of urine and feces sample collection. Dry matter intake species differences, when adjusted to metabolic body weight (kg $BW^{0.75}$; MW), were noted for ALF and C3G ($P < 0.01$), while the goats showed a difference between all three forages ($P < 0.05$; 61.6, 31.0 and 46.2 g/(d $kg^{0.75}$) for ALF, C3G and C4G, respectively), the llamas showed a difference between the grasses (40.4, 52.1 and 38.5 g/(d $kg^{0.75}$) for ALF, C3G and C4G, respectively). Digestible DM relative to MW (DDM/MW) was higher for ALF and C4G for the goats versus the llamas ($P < 0.03$; 42.5 and 29.0 g/(d $kg^{0.75}$) for goat ALF and C4G and 27.9 and 23.2 g/(d $kg^{0.75}$) for the llama ALF and C4G, respectively). Llamas had a higher DDM/MW for the C3G, 19.6 and 28.9 g/(d $kg^{0.75}$) than goats. Both animal species were in positive N balance for all three forages; llamas and goats retained more N on the high-protein ALF, 0.60 and 0.22 g/(d $kg^{0.75}$), respectively, than they did on either of the grasses ($P < 0.05$; 0.15 and 0.04 g/(d $kg^{0.75}$) for C3G and 0.35 and 0.14 g/(d $kg^{0.75}$) for C4G). Unexpectedly, however, both species retained more N on C4G than on C3G. These results demonstrate that, under these circumstances, llamas do not have a higher digestive efficiency than goats, and goats retained more DM and N than llamas. Thus the goats appear to be more efficient on these forages than the llamas. Feeding strategy and morphology difference may account for these findings.

Keywords: Digestibility; N balance; Alfalfa; Grass hays; Llamas; Goats

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1. Introduction

There have been many questions regarding the relative digestion efficiencies of pseudoruminant llamas (three compartment stomach) and pecoran ruminants (true ruminants; four compartment stomach) such as goats and sheep (San Martin and Bryant, 1989; Warmington et al., 1989; Sponheimer et al., 2003). Some have suggested that llamas and their close relative, the alpaca, have superior digestive capabilities compared to pecoran ruminants (Hintz et al., 1973; San Martin and Bryant, 1989), while others have found no differences between these taxa (Hintz et al., 1976). Dulphy et al. (1997) and Warmington et al. (1989) found no difference in DMD between llamas and sheep fed a high CP diet, but suggested that llamas are more efficient on low-quality feeds because they lose less urinary N than do ruminants. Under confined laboratory conditions camelids have been reported to have a higher efficiency in extracting energy and protein from forages than pecoran ruminants (Warmington et al., 1989; San Martin and Bryant, 1989).

Grasses can be classified by the photosynthetic pathway they use. In C_3 plants, the first photosynthetic products have 3-carbon structures, while the first products of C_4 plants have 4-carbon structures. C_4 grasses are found in all tropical grasslands and are dominant in warm-season temperate grasslands. C_4 forage has thinner leaves, more bundle sheaths and smaller interveinal distances (Heckathorn et al., 1999). This generally equates to higher cellulose and higher lignin content, and as a result, a decrease in digestibility compared to C_3 grasses (Minson, 1971). A more detailed description of C_3 and C_4 photosynthesis can be found in Ehleringer and Cerling (2002).

This experiment was conducted to investigate the relative digestive capabilities and N retention of llamas (*Lama glama*) and goats (*Capra hircus*) under laboratory conditions fed a dicot forage alfalfa (*Medicago sativa*), a temperate monocot grass (tall fescue, *Festuca arundinacea*). In addition we wanted to determine taxa differences in digestive capabilities between monocots using a C_3 photosynthetic pathway grass (tall fescue) and a tropical C_4 photosynthetic pathway grass (coastal Bermuda, *Cynodon dactylon*) of similar protein and fiber content.

2. Materials and methods

Four llamas (2 yrs old; 125 ± 7.3 kg BW) and four Boer-cross goats (2 yrs old; 53 ± 8.4 kg BW) were obtained from the Brigham Young University herds in Provo, Utah. The animal metabolism room was maintained at 18 °C and lighting was on a 12:12 h on:off cycle. Prior to starting the experiment each animal was introduced to the metabolism crates for fourteen d, during which time they were exercised daily, fed ad libitum grass hay (mid-bloom tall fescue, *Festuca arundinacea*) and ad libitum water. The experiment consisted of every animal being fed each of the three forages during three treatment periods. The three forage hays fed were a mid-bloom alfalfa (*Medicago sativa*; ALF), a mid-bloom tall fescue (*Festuca arundinacea;* C3G) and mid-bloom Bermuda grass (*Cynodon dactylon*; C4G). Forage chemical analysis was performed at a commercial lab (DHI Forage Testing Laboratories, Dairy One, Inc., Ithaca, NY) using wet chemistry procedures for CP, ADF, NDF, lignin, NSC, fat and ash (Table 1). Each forage hay was chopped to a 5 cm fiber length, thoroughly mixed, then stored to reduce any variation when fed during the experiment. The forage treatments were tested during the same season in the same eight animals, thereby minimizing artifacts due to changing environmental conditions and intraspecific variability (Rymer, 2000). All animals were fed each experimental forage for 21 d prior to a 5 d collection period. Feed was provided at 12-h intervals at approximately 100% ad

Table 1
Composition data for mid-bloom alfalfa hay (*Medicago sativa*), a mid-bloom tall fescue hay (*Festuca arundinacea*) and mid-bloom coastal Bermuda grass hay (*Cynodon dactylon*)

Components	Forage hay (% DM[a])		
	Alfalfa	Tall fescue	Bermuda
CP (%)	20.5	10.4	10.3
ADF (%)	36.6	36.6	28.5
NDF (%)	51.5	60.4	63.0
Lignin (%)	6.5	5.2	5.6
Non-structural carbohydrates (%)	27.2	15.6	18.2
Crude fat (%)	3.7	2.7	1.5
Ash (%)	10.8	11.5	9.2

[a] Composition determined by DHI Forage Testing Laboratories, Dairy One, Inc., Ithaca, NY using wet chemistry procedures and are expressed as a percent of DM. Dry matter content was 92, 93 and 93% for the alfalfa, fescue and Bermuda hays.