

CHARACTERIZATION OF LEGUME AND GRASS RESIDUES FOLLOWING IN VITRO AND IN SACCO RUMINAL DIGESTION

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ABSTRACT

Objectives were to characterize the influence of forage species and maturity on dry matter degradation. Averaged across maturities, alfalfa and red clover were lower in NDF content (39 and 30% NDF, respectively) than reed canarygrass and timothy (59 and 54% NDF, respectively). The NDF of the DM residues in grass remained relatively unchanged over time, while NDF of the DM residue in legume increased rapidly for 9 h before becoming relatively constant. Alfalfa incubated in vitro (42% NDF) compared to reed canarygrass (58% NDF) contained more ND soluble material (39% vs. 25%), and more pepsin soluble material (22 vs. 18%). Legumes contained much more soluble fiber than did grasses. Differences in residue composition between legumes and grasses may account for differences in rates of digestion.

KEYWORDS

Legume, grass, digestion, fiber

INTRODUCTION

National Research Council (NRC, 1989) recommendations use minimum dietary allowances of cell-wall constituents, or neutral detergent fiber (NDF), and assume NDF is digested at the same rate regardless of the type of feed (NRC, 1989). However, Varga and Hoover (1983) observed differences in rates and extents of NDF degradation across 22 different forages. They demonstrated that forages which had rapid rates of NDF degradation did not necessarily have high percentages of total NDF degraded. In general, legumes had faster NDF degradation rates than grasses. Grasses, however, degraded more extensively than legumes.

Hoffman et al. (1993) calculated the percentage of NDF remaining after ruminal incubation in grasses and legumes. The NDF % of the original dry matter was similar for grasses and legumes at 3, 6, 9, and 12 h of incubation. After 24 h, NDF ceased degrading in legumes, while NDF degradation in grasses continued. Our objectives were to characterize some of the differences in degradation between legumes and grass.

MATERIALS AND METHODS

Two legume species, alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pratense* L.), and two grass species, reed canarygrass (*Phalaris arundinacea* L.) and timothy (*Phleum pratense* L.), were harvested each at three stages of maturity (Table 1). Legumes were harvested at early to mid-vegetative stage, flower bud stage, and early to mid-bloom (Nelson and Moser, 1995). Grasses were harvested at early to mid-vegetative stage, boot stage, and late anthesis (Simon and Park, 1983). Samples (0.5 g) were evaluated for NDF, acid detergent fiber (ADF), and lignin (Van Soest et al., 1991) crude protein, neutral detergent insoluble nitrogen, and acid detergent insoluble nitrogen (Licitra et al., 1996). In addition, changes in NDF as a percent of original DM of two legume species and two grasses species during in vitro digestion were determined.

For in vitro digestion samples (0.5 g) were incubated in buffered rumen fluid according to the stage 1 procedure described by Marten and Barnes (1980) for 0, 3, 9, 24, and 48 h. Residues were extracted in neutral detergent solution. In sacco analyses were determined according to Cherney et al., 1990.

Dry matter disappearance, NDF disappearance, acid-pepsin insoluble residue (Tilley and Terry, 1963) were determined for one legume (alfalfa, bud stage, 42% NDF) and one grass (reed canarygrass, boot stage, 58% NDF). Soluble fiber of the residue was approximated by treatment with ethanol (40%) after in vitro incubation (Hall et al., 1995). Residues insoluble in 40% ethanol were meant to give a rough approximation of soluble fiber as a portion of the original DM. Soluble fiber (Hall et al.,

1995) was determined for all legume and grass samples. Statistical design was a randomized complete block with a factorial arrangement of treatments. Unless otherwise noted, significance was declared at $P < 0.05$.

RESULTS

There were large differences in chemical composition among the samples, as would be expected (Table 1). At maturity 1 (vegetative stage), $51.6 \pm 1.74\%$ of the alfalfa DM residue and $54.7 \pm 2.86\%$ of the red clover DM residue at 3 h incubation was NDF (Figure 1). In contrast, reed canarygrass DM residue was $73.0 \pm 0.53\%$ NDF and timothy DM residue was $76.5 \pm 0.35\%$ NDF at 3 h.

At later times during in sacco incubation, there were relatively smaller differences in NDF content of DM residues in first maturity legumes versus grasses (Figure 3). By 9 h, alfalfa, red clover, reed canarygrass, and timothy were not different. Mid- and late-maturities (maturities 2 and 3) had similar degradation patterns, but degradation was not as complete and differences between grasses and legumes were not as large. In vitro sample residues followed the pattern observed in sacco, with relatively small differences between NDF% of alfalfa and grass DM residues. Overall, NDF concentration of in vitro DM residues was lower than in sacco residues.

The portion of dry matter residue insoluble in 40% ethanol decreased at each time for reed canarygrass (84% to 52% for 0 to 24 h). At 0 h, there was a difference between alfalfa and reed canarygrass. At 9 h, however, there was no longer a difference. Soluble fiber analyses were determined for all legumes and grasses to approximate soluble fiber [pectins, b-glucans and gums (Van Soest, 1994)]. Soluble fiber content of maturity 2 alfalfa was 13.7%, red clover was 14.5%, and the maturity 2 reed canarygrass was 2.6% (of original DM, starch corrected) (Table IV). Timothy had higher soluble fiber content than was expected (10.7% for maturity 2); however, this material was probably not pectin (Van Soest, 1995).

DISCUSSION

Large relative differences in the percent NDF of DM residues of ruminally incubated legumes versus grasses existed at 3 h but decreased by 9 h. Across the three maturities, the pattern of relative difference between legume and grass NDF of DM residue was consistent. However, this pattern shifted towards higher NDF percentages as maturity increased. These results indicate that differences between grasses and legumes are consistent, regardless of maturity.

Degradation patterns of NDF as a percent of the DM residue suggest that legumes contain NDF material which is soluble within the first 9 h of ruminal incubation, but which is not immediately soluble. Dry matter disappearance, NDF disappearance, and acid-pepsin digestibility did not account for differences observed between legumes and grasses. However, treatment with 40% ethanol suggests that the relative difference evident in the initial ruminal fermentation studies may be related to soluble fiber. Furthermore, chemical evaluation indicated that mid-maturity alfalfa had five times more soluble fiber than mid-maturity reed canarygrass. Pectin, a major component of soluble fiber, is known to be more abundant in legumes than in grasses (Van Soest, 1994). Evidence in this study suggests that pectin may be responsible for differing DM degradation patterns between legumes and grasses. Other components of soluble fiber, particularly b-glucan and other gums, are less likely to cause differences between legume and grass DM degradation because b-glucan and such gums are not lignified and are readily soluble (Van Soest, 1994). This evidence suggests that soluble fiber may be responsible for different degradation patterns observed.

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Table 1
Harvest dates and chemical compositions of Alfalfa (*Medicago sativa L.*), red clover (*Trifolium repens L.*), reed canarygrass (*Phalaris arundinacea L.*), and timothy (*Phleum pratense L.*)^a

Forage	Harvest Date	Maturity	NDF (% of DM)	ADF (% of DM)	Lignin (% of DM)	CP (% of DM)	NDIP (% of CP)	ADIP (% of CP)	Soluble fiber (% of DM)
Alfalfa	5-19-94	1	26.6	22.2	4.39	26.5	3.3	1.8	16.3
	6-9-94	2	41.8	34.8	8.40	19.1	4.4	3.1	13.8
	6-17-94	3	50.0	41.9	10.97	15.3	6.7	4.6	12.3
Red clover	5-19-94	1	26.9	18.8	3.84	29.1	12.1	2.0	13.3
	5-29-94	2	29.2	22.5	4.49	21.8	9.7	2.5	14.5
	6-10-94	3	33.0	26.3	5.84	18.3	7.5	2.6	13.7
Reed	5-19-94	1	48.0	26.3	1.82	25.4	6.8	1.0	2.7
Canarygrass	5-25-94	2	57.6	31.8	2.91	20.1	7.4	1.7	2.6
	6-17-94	3	70.3	43.6	7.42	11.1	10.2	5.5	2.8
Timothy	5-19-94	1	46.3	25.2	3.18	13.1	12.8	1.9	11.3
	5-26-94	2	52.6	28.0	3.69	10.2	13.7	3.1	10.7
	7-27-94	3	63.0	37.7	8.07	5.8	11.6	6.6	15.4

^aFor legumes maturity 1= early to mid-vegetative stage, 2=flower bud stage, and 3=early to mid-bloom. For grasses maturity 1=early to mid-vegetative stage, 2=boot stage, and 3=late anthesis. NDF=neutral detergent fiber, ADF=acid detergent fiber, CP=crude protein, NDIP=neutral detergent insoluble protein, ADIP=acid detergent insoluble protein.

Figure 1
Percent of NDF of in sacco DM residue for alfalfa, red clover, reed canarygrass, and timothy at maturity 1(a), maturity 2 (b), and maturity 3 (c). For legumes, maturity 1 is early to mid-vegetative stage, maturity 2 is bud stage, and maturity 3 is early to mid-bloom. For grasses maturity 1 is early to mid-vegetative, maturity 2 is boot stage, and maturity 3 is late anthesis. Bars indicate standard deviations; standard deviations smaller than the width of the symbols do not show.

