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PREDICTION OF INTAKE OF HAY DIFFERING IN SPECIES AND MATURITY BY GOATS

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Abstract

Eight species of forage, a cool-season perennial(*Festuca arundinacea*) and annual grass (*Triticum aestivum*), four warm-season perennial grasses (*Bothriochloa caucasica, B. ischaemum, Cynodon dactylon, and Tripsacum dactyloides*), a warm season annual (*Digitaria sanguinalis*) and a perennial legume (*Medicago sativa*), were cut at two or three maturities to provide a wide array of quality difference (n=20). Twenty wether goats (*Capra hicus*) were fed the hays in four different trials using an incomplete block so that each hay was fed to four different goats. Alfalfa produced the highest DM, but lowest neutral detergent fiber (NDF) intake. Intake was best predicted with eating time, passage rate and lag time, and hay CP and ADF (R^2 =0.57). Digestibility was best predicted with percentage acid detergent fiber (ADF), permanganate lignin (PML) and CP, and ruminating time (R^2 =0.35). Weight gain (g/d) could be predicted with digestible dry matter intake (r^2 =0.42; $P < 0.001$). Regression curves were different ($P < 0.05$) among forage types.

Keywords: Intake, digestibility, rate of passage, eating behavior, forage chemistry

Introduction

Nutritive potential of forages include their limitations to be consumed and digested (Coleman et al., 1999). Holmes et al. (1966) and Lippke (1980) demonstrated that when animals consume forages alone, their productivity (rate of gain) is related to digestible dry matter intake. Regulation of voluntary intake continues to be one of the major topics in ruminant nutrition because of the interactions of the animal and its demand and the limitations imposed by the feed, particularly when the feed is forage. Balch (1969) demonstrated the efficacy of rumination time in the processing of forage and its importance to the limitations forages impose on their intake and processing by the ruminant. We initiated this research to determine the relationships among forage chemistry, eating and ruminating behavior, rate of passage, DM intake, and nutrient digestibility.

Material and Methods

Twenty hays were harvested to provide a wide array of different species and maturities which would create differences in quality. The hays were represented by eight different species each cut at two or three maturities each. Species were selected to provide variation in plant type and included a cool-season perennial grass, tall Fescue (*Festuca arundinacea*), a cool-season annual grass, wheat (*Triticum aestivum*), four warm-season perennial grass species, caucasian bluestem (*Bothriochloa caucasicus),* plains bluestem *(B. ischaemum),*bermudagrass *(Cynodon dactylon),* and eastern gamagrass *(Tripsacum dactyloides*)*,* a warm season annual, crabgrass (*Digitaria sanguinalis*), and a perennial legume, alfalfa (*Medicago sativa*). Just before the experimental trials, about 100 kg of each hay was passed through a hammermill with a 3.5-mm screen to reduce particle size to approximately 2.5 cm in length. Alfalfa was ground without a screen to reduce shattering.

Twenty, Alpine wether goats were placed in wooden crates suitable for separation of feces and urine. Each goat was randomly assigned to one of the hay sources for trial 1. They were offered their respective hay at 0800 each day to achieve refusal of 10%. After 10 days for diet adaptation, intake was recorded as feed consumed during days 8 through 15, and feces were collected from days 11 through 15. On day 10, each animal was given 200 g of their respective hay marked with Yb according to Ellis et al. (1994).

All samples of hay, refusals and feces were dried at 65^{o}C and ground to pass a 1-mm screen, and were subsequently analyzed for DM, ash, and CP according to AOAC (1984) and for NDF, ADF and PML according to Goering and Van Soest (1970). Daily DM and nutrient intake and nutrient digestibility were calculated for each animal.

During the fourth day of collection, observations were made of each animal every five minutes for 24 hours. At each 5 min interval, the activity of each goat was recorded as eating, chewing, standing, lying or drinking.

Following the first trial, the animals were re-randomized to a different hay, and the procedures were repeated. They were repeated for a third and fourth trial so that each hay was fed to four different goats during the four trials. The experimental design was a balanced incomplete block. Rate of passage was determined by regressing Yb concentration in the feces on time from dosing using the NLIN procedure of SAS (1990). The model was the two-compartment, age independent model described by Ellis et al. (1994). Intake, digestion coefficients, rate of passage, and time spent eating and rumination per gram of NDF intake (NDFI) were analyzed statistically using the GLM procedure of SAS (1990). The REG procedure with stepwise option was used to develop equations to predict DM intake and digestibility using forage chemistry, animal behavior, and passage rate.

Results and Discussion

Crude protein was highest ($P < 0.01$) in alfalfa and lowest ($P < 0.01$) in warm-season perennial grasses and wheat hay (Table 1). Perennial grasses contained the highest levels of NDF ($P < 0.01$) . Alfalfa and crabgrass contained lower levels of ADF than other forages ($P < 0.05$).

Dry matter intake was highest and NDFI was lowest for the legume hays (Table 1). The warm-season annual grass hay, crabgrass, was readily consumed and had the highest digestibility of the grasses. Within hay, animal variation averaged 2.71% (range 1.04-7.71) and 10.4% (range 2.5-29.7) of the mean (coefficient of variation) for digestibility and intake, respectively.

Rumination time per unit of NDFI was the first variable selected to predict intake and accounted for 25% of the variation. Since NDFI is part of DM intake, we elected to leave it out of the selection procedure and re-start. The first variable then selected was passage lag ($r^2 = 0.2$; $P < 0.05$; Table 2). Others contributing to the explanation of 57% ($P < 0.05$) of the variation included CP and ADF content of the hay, minutes spent eating, and rate of passage. Intake is dependent on animal requirements, animal preferences, and on the potential for the forage to be eaten and processed.

Digestibility was mostly affected by hay chemistry. The constituents ADF, PML, and CP were selected along with rumination time (2^{nd} selection) by the stepwise procedure, but the four variables accounted for only 35% of the variation (Table 2). Lippke, 1980 found that ADF and CP were important for predicting digestible DM intake.

Ultimately, the desired prediction is for performance, growth, milk or wool. Forage quality indexes that have been proposed usually include a measure of intake, either directly or relative to a common feed and digestibility of DM or energy (Crampton, 1957; Moore, 1994). We regressed growth rate ($g^{\cdot}d^{-1}$) on digestible DM intake (DDMI) using individual animals (n=78) as the unit and the resulting equation was:

$$\text{Growth rate} = -0.22 + 0.0022 * \text{DDMI } (g^{\cdot}kgBW^{-1}) \qquad r^2 = 0.42\ (P < 0.001).$$

The lack of fit is greater than that observed by Holmes et al. (1966) or Lippke (1980), but individual animals rather than forage means was used in the current study.

In conclusion, typical relationships were found between nutritive potential and forage chemistry. Forage chemistry provided little insight for explaining intake in goats but was quite useful for predicting digestibility. Intake was better related to measures of resistance to breakdown (rumination time and passage rate) than simple measures of forage chemistry.

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Table 1- Chemical composition, intake, digestibility, rate of passage and chewing behavior for hays by category.

	Legume	Grasses: Warm-season perennial	Grasses: Cool-season perennial	Grasses: Warm-season annual	Grasses: Cool-season annual
Number of species	1	4	1	1	1
Total hays	2	10	3	3	2
Chemical composition, g kg^{-1}					
CP	207† ± 13	74 ± 14	100 ± 31	92 ± 10	77 ± 10
NDF	445 ± 53	725 ± 36	696 ± 90	648 ± 28	699 ± 73
ADF	319 ± 45	422 ± 30	406 ± 57	385 ± 33	441 ± 68
PML‡	67 ± 19	68 ± 15	65 ± 14	66 ± 10	67 ± 21
Nutritive parameters§					
DM intake, g kg BW^{-1} d^{-1}	27.5 ± 6.0	21.7 ± 5.2	20.4 ± 5.1	24.1 ± 3.5	19.4 ± 6.6
DM digestibility, g kg^{-1}	608 ± 42	533 ± 47	523 ± 100	563 ± 40	524 ± 29
CP digest., g kg^{-1}	715 ± 32	465 ± 91	562 ± 95	505 ± 66	473 ± 68
NDF digest., g kg^{-1}	548 ± 86	583 ± 52	524 ± 119	580 ± 44	538 ± 44
Eating time, min	139 ± 38	199 ± 38	196 ± 57	208 ± 54	204 ± 59
Ruminating time, min	347 ± 80	411 ± 93	470 ± 133	407 ± 93	474 ± 92
Ruminating, min g NDF^{-1}	0.95 ± 0.15	0.97 ± 0.34	1.25 ± 0.30	1.00 ± 0.33	1.36 ± 0.26
Passage rate, g g^{-1} hr^{-1}	0.047 ± 0.018	0.037 ± 0.01	0.040 ± 0.001	0.048 ± 0.015	0.033 ±0.008
Time delay, hr	11.1 ± 2.0	16.2 ± 5.5	10.5 ± 7.8	16.5 ± 11.3	14.1 ± 3.9

†Mean ± standard deviation. .
‡Permanganate lignin.
§Based on four goats per hay.

Table 2- Prediction of nutrient intake and digestibility from forage chemistry and eating behavior.

Dry matter intake, g·kg BW^{-1}			Dry matter digestibility, g·kg^{-1}		
X†	b	CV	X	b	CV
Passage lag time, hr	-0.38	0.20	ADF[c], g DM^{-1}	- 0.53	0.20
Passage lag time, hr	-0.38		ADF, g DM^{-1}	- 0.51	
ADF, g DM^{-1}	-0.04	0.33	Rumination, min kg $NDFI^{-1}$‡	-18.9	0.25
Passage lag time, hr	-0.42		ADF, g DM^{-1}	- 0.43	
ADF, g DM^{-1}	-0.06		Rumination, min kg $NDFI^{-1}$	-18.8	
Eating time, min	0.04	0.47	PML§, g DM^{-1}	- 0.79	0.29
Passage lag time, hr	-0.41		ADF, g DM^{-1}	-0.14	
ADF, g DM^{-1}	-0.06		Rumination, min kg $NDFI^{-1}$	-19.0	
Eating time, min	0.05		PML, g DM^{-1}	- 1.09	
Passage rate, g g^{-1} hr^{-1}	94.1	0.53	Crude protein, g DM^{-1}	0.48	0.35
Passage lag time, hr	-0.38				
ADF, g DM^{-1}	-0.04				
Eating time, min	0.05				
Passage rate, g g^{-1} hr^{-1}	87.6				
Crude protein, g DM^{-1}	0.03	0.57			

†X = independent variable; b = regression coefficient; CV = coefficient of variation.
‡Neutral detergent fiber intake.
§Permanganate lignin.