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DIGESTA KINETICS OF STEERS FED FORAGE KOCHIA (*KOCHIA PROSTRATA*) IN A LOW QUALITY FORAGE DIET[1]

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ABSTRACT: Forage kochia is a shrub that is useful in the Western US for rehabilitating degraded rangelands. Little information is known about its nutritional value for grazing beef cattle. The objective of this study was to evaluate digesta kinetics in diets using different ratios of forage kochia and tall wheatgrass (*Agropyron elongatum*). Four ruminally fistulated beef steers (mean initial BW = 348 kg) were allocated to four treatments in a 4 × 4 Latin square design. Treatments were: 100% wheatgrass (0K); 75% wheatgrass:25% kochia (25K); 50% wheatgrass:50% kochia (50K); and 25% wheatgrass:75% kochia diet (75K). Steers were fed twice daily at 110% of mean intake over the previous 5 d. Steers were allowed an 11 to 13 d adaptation period. Feed intake and fecal output were measured and sampled during the following 7 d. Digesta kinetics was determined using a pulse dose of ytterbium ($YbCl_3$) as an external marker. Each steer was dosed with tall wheatgrass labeled with $YbCl_3$ just before feeding on the morning of the last fecal collection. The Yb-labeled forage was placed in different locations within the rumen. Rectal fecal grab samples were collected at 0 (before Yb was dosed), 4, 8, 12, 16, 20, 24, 28, 32, 36, 42, 48, 54, 60, 72, 84, 96, 108, and 120 h post dosing. Data were analyzed in a Latin square-design in the MIXED procedure of SAS. As the amount of kochia increased in the diets, passage rate increased linearly ($P = 0.0006$) and mean retention time decreased linearly ($P = 0.0009$). Animals on the 75K diet had the highest passage rate and the lowest mean retention time. Digestive tract fill on a weight basis ($P = 0.06$) and on a percentage of body weight basis ($P = 0.08$) tended to increase linearly as the amount of kochia increased in the diet. We previously reported that intake and rate of DM and NDF digestion increased linearly as kochia increased in the diet. Fill followed the pattern of intake. Kochia affects digestive tract kinetics in a low quality diet by increasing the rate of passage and decreasing retention time as the level of kochia increases in the diet.

Key words: Beef cattle, forage utilization, forage kochia

Introduction

Forage kochia (*Kochia prostrata*) is native to the arid and semiarid regions of Central Eurasia (Keller and Bleak, 1974) and has adapted well to a variety of environmental conditions in the western United States. Forage kochia is a shrub that is useful in the Western US for rehabilitating degraded rangelands. However, little information is known about its nutritional value for grazing beef cattle.

Fall and winter grazing studies have been conducted on forage kochia (ZoBell et al., 2003; Koch and Asay, 2002) but little is known on the effects it will have on digestive kinetics in grazing animals.

The objective of this study was to evaluate digesta kinetics in diets of beef cattle using different dietary ratios of forage kochia and tall wheatgrass (*Elytrigia elongata*) straw.

Materials and Methods

Four ruminally fistulated beef steers (mean initial BW = 348 kg) were allocated to one of four treatments in a 4 × 4 Latin square design. The 4 treatments consisted of varying mixtures of tall wheatgrass straw and forage kochia mixed to provide diets of: 100% wheatgrass (0K); 75% wheatgrass:25% kochia (25K); 50% wheatgrass:50% kochia (50K); and 25% wheatgrass:75% kochia diet (75K) on an as-fed basis. The forage kochia was from an irrigated, pure stand with the intent of the seed being harvested but was instead harvested as hay at full maturity with the seed attached for the purpose of this study. The tall wheatgrass straw was harvested in late fall from an irrigated, pure stand after seed had been harvested. Both forages were intended to mimic stockpiled forage used for winter grazing. The tall wheatgrass and forage kochia were chopped to an average length of 3 cm. Treatment diets were fed as mixed rations.

Steers were housed in individual metabolism crates (2.4 x 1.1 m) located inside a shed that was enclosed on three sides and was open facing the south. Steers were allowed free access to water and a trace-mineralized salt block (Table 1). Steers were fed twice daily at 0700 and 1900. Orts were collected and weighed daily before the morning feeding. Steers were then offered 110% of mean intake over the previous 5 d. The experimental protocol was approved by the Institutional Animal Care and Use Committee at Utah State University.

Experimental periods were 24 to 26 d, with 11 to 13 d of adaptation. Period 1 consisted of a 13-d adaptation period to allow steers to adjust to their respective treatments. Period 2 adaptation was reduced to 12 d and periods 3 and 4 were reduced to 11 d because of a limited supply of forage kochia. The following 7-d period was used to measure feed intake and total fecal output to estimate in vivo digestibility (Stonecipher et al., 2004).

Digesta kinetics were determined using a pulse dose of ytterbium ($YbCl_3$) as an external marker (Krysl et al., 1985;

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Teeter et al., 1984). For period 1, 800 g of tall wheatgrass (as is), subsampled from the feed pile, was soaked in a prepared Yb solution that contained 20 g of $YbCl_3 * 6 H_2O$ dissolved in deionized water. For periods 2, 3, & 4, 1000 g of wheatgrass (as is) was soaked in a prepared Yb solution that contained 30 g of $YbCl_3 * 6 H_2O$ dissolved in deionized water. The solution was then brought to volume with enough deionized water to sufficiently cover the forage. The wheatgrass was soaked for 24 h. Excess water was poured off and the forage was washed with deionized water every hour for a 6-h period. Forage was then dried in a forced-air oven at 60º C for 48 h. On the morning of the last total fecal collection, just before feeding, each steer was pulse-dosed with tall wheatgrass labeled with $YbCl_3$. The labeled forage was administered into various sites in the rumen to achieve uniform dispersion.

For period 1, steers were dosed with 150 g of forage containing 0.311 g Yb g^{-1} forage DM via rumen fistula. For periods 2, 3, & 4, steers were dosed with 180 g of forage containing 0.477 g, 0.442 g, and 0.405 g of Yb g^{-1} forage DM, respectively, via rumen fistula. Rectal fecal grab samples were collected at 0 h, before Yb was dosed, and at 4, 8, 12, 16, 20, 24, 28, 32, 36, 42, 48, 54, 60, 72, 84, 96, 108, and 120 h post dosing. Fecal samples were stored at -20º C until laboratory analysis.

Laboratory Analysis. Feed samples were dried at 60º C and ground in a Wiley mill to pass a 1-mm screen. Subsamples were dried overnight at 105ºC to determine DM (AOAC, 1996). Feed samples were analyzed for NDF and ADF content using procedures modified for use in an Ankom 200 Fiber Analyzer (Ankom Technology, Fairport, NY). Feed samples were analyzed for N content with the combustion method (AOAC, 1996) using a N analyzer (Leco, St. Joseph, MI) and nitrogen was multiplied by 6.25 to determine CP. Yb-labeled fecal samples were dried at 60º C in a forced-air oven. Fecal samples were then ground through a Wiley mill to pass a 1-mm screen. Duplicate samples were dried at 105ºC to determine DM content (AOAC, 1996) and then ashed overnight at 500º C in a muffle furnace and Yb was extracted following the procedure of Ellis et al. (1980). Yb concentration was then determined by inductively coupled plasma emission spectroscopy using a Thermo Jarrell Ash Iris Advantage (Franklin, MA).

Statistical analysis. Fecal Yb concentration curves were fitted to a one-compartment model (Pond et al., 1987) using the nonlinear regression procedure of SAS (PROC NLIN, SAS Institute, Cary, NC). Passage rate, retention times, and gastrointestinal fill were calculated from the nonlinear regression results. The response of passage rate, retention time, and gastrointestinal fill to wheatgrass:kochia treatment were analyzed using the MIXED procedure of SAS in a Latin square-repeated measure design. The model included treatment, period, and steer. Steer was designated a random effect and period was designated a repeated measure. Linear and quadratic polynomial contrasts were constructed to evaluate the influence of increasing levels of forage kochia in the diet.

Results and Discussion

The low CP and high fiber of the tall wheatgrass typified a low-quality, dormant forage available for winter grazing (Table 2). The higher nutrient concentration, particularly CP, in the forage kochia should induce a positive associative effect, leading to improved fermentation of the fiber in the tall wheatgrass straw.

Passage rate increased linearly (P = 0.0006) and mean retention time decreased linearly (P = 0.0009) as the amount of forage kochia increased in the diet (Table 3). Animals on the 75K diet had the highest passage rate and the lowest mean retention time. Consuming forages with large amounts of stem material could slow passage rate and increase retention times (Hess et al., 1994). The tall wheatgrass fed in this study consisted of a large amount of stem material and passage rate was slowest and mean retention time the highest on diets consisting of only tall wheatgrass (0K).

We previously reported that increasing levels of forage kochia caused a linear increase in the rate of digestion of DM and NDF of the tall wheatgrass (Stonecipher et al., 2004). These concomitant increases in rates of digestion and passage suggest that forage kochia had a positive associative effect on utilization of the tall wheatgrass.

Digestive tract fill on a weight basis (P = 0.06) and on a percentage of body weight basis (P = 0.08) tended to increase linearly as the amount of forage kochia increased in the diet (Table 3). We previously reported that intake increased linearly as kochia increased in the diet (Stonecipher et al., 2004). Fill followed the pattern of intake. Forage kochia has the ability to increase CP supplied to livestock in the winter grazing period (Welch and Davis, 1984; ZoBell et al., 2003). Supplementing diets with protein has been reported to increase particulate passage rates (Hess et al., 1994) and also increase forage intake and digestibility (McCollum and Horn, 1990). Passage rate is believed, to an extent, to be responsible for the regulation of intake (Merchen, 1988). In this study, passage rate and intake increased in direct proportion as forage kochia was added to the diets. McCollum and Galyean (1985) and Caton et al. (1988) reported increases of intake in relation to increases in passage rate and decreases in retention time.

Implications

Incorporating forage kochia into a low-quality grass diet affected digestive tract kinetics by increasing the rate of passage and decreasing retention time as the level of kochia increased in the diet. Forage kochia can be used with poor quality forages to help increase digesta turnover rates, which will contribute to increased nutrient intake by livestock grazing low-quality forages.

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Table 1. Composition of trace-mineralized salt block [a]

Item	Concentration
Salt (NaCl) minimum	95.5 %
Salt (NaCl) maximum	98.5 %
Zinc (Zn) minimum	3,500 ppm
Iron (Fe) minimum	2,000 ppm
Manganese (Mn) minimum	1,800 ppm
Copper (Cu) minimum	280 ppm
Copper (Cu) maximum	420 ppm
Iodine (I) minimum	100 ppm
Cobalt (Co) minimum	60 ppm

[a] Ingredients: salt, zinc oxide, ferrous carbonate, manganous oxide, magnesium oxide, copper oxide, calcium iodate, cobalt carbonate, red iron oxide for color.

Table 2. Chemical composition of tall wheatgrass and forage kochia used in diets

Item	Wheatgrass	Kochia
DM, %	94.1	93.6
	------ % of DM ------	
CP	3.6	9.6
NDF	77.7	53.8
ADF	50.6	32.2

Table 3. Influence of forage kochia on digesta kinetics for cattle consuming tall wheatgrass straw. All results reported on a DM basis

	Treatment						Contrast	
Item	0K	25K	50K	75K	SE	T[a]	L[b]	Q[c]
Particulate passage rate, % h^{-1}	1.81	2.00	2.34	2.47	0.181	0.004	<0.001	0.75
Mean particulate retention time, h	97.6	84.1	73.7	68.5	6.07	0.005	<0.001	0.30
Gastrointestinal fill, kg	2.97	3.34	3.16	3.66	0.186	0.15	0.06	0.73
Gastrointestinal fill, %BW	0.84	0.91	0.86	1.00	0.05	0.17	0.08	0.45

[a]T = ANOVA treatment effect.
[b]L = Linear effect.
[c]Q = Quadratic effect