CHROMIUM OR YTTERBIUM AS SINGLE MARKERS FOR ESTIMATING DUODENAL DIGESTA FLOW OF STEERS GRAZING WHEAT PASTURE

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Story in Brief

Duodenal digesta flow was estimated by reference to chromium (Cr_2O_3 powder) or ytterbium ($YbCl_3 \cdot 6H_2O$) labeled wheat forage, from samples obtained from eight steers (average body weight 1000 lbs) equipped with rumen and duodenal cannulae (T-type). Measurements were made over 2 periods during which the steers grazed immature and mature wheat forage. Effects of lasalocid supplementation (treatment) on duodenal flow of digesta during each stage of wheat forage maturity were also measured. Estimates of duodenal digesta flow were affected by marker, with significant two and three way interactions detected among marker and stage of maturity and marker, stage of maturity and treatment, respectively ($P<.10$). Measurements obtained in reference to ytterbium had lower coefficients of variation, accounted for a larger proportion of the total variation, resulted in a higher observed significance levels for main effect differences and resulted in significant interaction between stage of maturity and lasalocid supplementation ($P<.10$). Based on the selected criteria, Yb-labeled forage appears to be more effective than chromium as a single, particulate marker for measurement of duodenal digesta flow of steers grazing wheat pasture.

[Key Words: Chromium, Ytterbium, Digesta flow, Wheat pasture, Steers.]

Introduction

The accuracy of using chromium (Cr_2O_3 powder) as an external marker in combination with spot sampling of digesta to estimate flow of digesta along the gastro-intestinal tract of ruminants, has been a frequent and controversial topic of discussion. The primary concern is the apparent independent flow of chromium in relation to either the particulate or liquid phase of digesta. The rare earth ytterbium, as its salt $YbCl_3 \cdot 6H_2O$, has been used as an external particulate marker when bound to wheat forage (Mader et al., 1984). Under these conditions, Yb may more closely mimic the flow of particulate digesta than chromium. The objective of this study was to compare relative differences among estimated duodenal flow of nutrients obtained by using chromium oxide powder or ytterbium labeled wheat forage markers in steers grazing wheat pasture. In order to examine the ability of the markers to identify treatment differences, effects of stage of maturity of the wheat pasture and lasalocid supplementation on flow of nutrients were measured.

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Materials and Methods

Eight ruminally and duodenally (T-type) cannulated Hereford steers (approximately 1000 lbs. body weight) were allowed to graze a single paddock of wheat forage. Measurements of duodenal digesta flows were undertaken during the immature (March 7-27) and mature (April 22-May 14) stages of wheat forage maturity. Hand clipped wheat forage samples representative of each stage of maturity were labeled with $YbCl_3 6 \cdot H_2O$ by the immersion procedure described by Mader et al. (1984). Each steer received intraruminal dosages of known amounts of Yb-labeled wheat forage and Cr_2O_3 powder in gelatin capsules twice daily at 7:00 am and 7:00 pm. A total of six duodenal samples were collected at 4 h intervals beginning 10 days after dosing of markers was initiated. Samples were composited by weight over sampling times for subsequent analysis. Wheat forage and duodenal samples were freeze-dried, and together with Yb-labeled forage and Cr_2O_3, analyzed for marker concentrations utilizing atomic absorption spectophotometry. Nitrogen content of forage and duodenal samples was determined by the macro-Kjeldahl technique. Daily flow of digesta and nutrients to the duodenum was calculated assuming 100 percent recovery for each marker as follows:

$$\text{Duodenal Flow of Digesta} = \frac{\text{Daily Dose of Marker}}{\text{Marker Concentration in Duodenal Digesta}}$$

$$\text{Duodenal Nutrient Flow} = \text{Duodenal Flow of Digesta} \times \text{Nutrient Concentration of Duodenal Digesta}$$

The criteria used to compare estimates obtained from each marker were: (1) Coefficient of variation (C.V.); (2) Total amount of experimental variation accounted by the model (coefficient of determination, R^2); (3) Observed significance levels of difference among least square means of the two main effects; (4) Detection of interactions among the two main effects.

Results and Discussion

Least square means for flow of nutrients to the duodenum in reference to ytterbium and chromium are shown in table 1. Sources of variation and level of significance for the measurements are presented in table 2. While the marker by treatment (lasalocid) interaction was not significant, the two and three way interactions of marker by period and marker by period by treatment, respectively, for flow of OM and N to the duodenum were significant ($P<.10$). The presence of these interactions suggests a true difference between the measurements obtained in reference to chromium or ytterbium.

Even though the absence of absolute measurements makes interpretation of the data obtained with the two markers difficult, the criteria in table 2 should aid decisions relative to the appropriateness of the two markers. Measurements obtained from Yb-labeled wheat forage had a low C.V. and accounted for a greater proportion of the total variation (R^2), except for the flow of N to the duodenum (table 2). A higher level of significance for differences among main effect means was obtained for measurements in reference to ytterbium as compared with

Table 1. Ytterbium (Yb) vs chromium (Cr) as a single marker to estimate flow of nutrients to the duodenum of steers grazing wheat forage at two stages of maturity, with and without lasalocid supplementation (LS means; n=4).

			Duodenal Flow			
			Organic Matter		Nitrogen	
Stage of Maturity	Lasalocid (Mg/head/d)	Marker	lb/day	% intake	g/day	% intake
Immature	0	Yb	5.43^{a}	30.9^{a}	180^{ab}	47.3^{a}
		Cr	7.75^{b}	44.1^{b}	257^{c}	67.5^{b}
	300	Yb	5.57^{a}	33.2^{a}	190^{b}	52.4^{a}
		Cr	9.35^{c}	55.7^{c}	319^{d}	87.9^{c}
Mature	0	Yb	7.17^{b}	44.9^{b}	163^{a}	84.7^{c}
		Cr	9.23^{c}	57.8^{c}	209^{c}	108.8^{d}
	300	Yb	7.45^{b}	55.4^{c}	171^{ab}	106.1^{d}
		Cr	9.12^{c}	68.0^{d}	211^{c}	131.1^{e}
SE			.359	2.3	9.5	4.2

^{a,b,c,d,e}Means in a column with different superscripts are different P<.10.

chromium, with the exception of N flow to the duodenum at both stages of maturity (table 2). The stage of maturity by lasalocid interaction for flow of nutrients to the duodenum relative to intake was significant (P<.10) when measured in reference to ytterbium (table 2).

In summary, based on the selected criteria, Yb-labeled wheat forage appears to be more effective than chromium as a single, particulate marker for measurement of duodenal digesta flow of steers grazing wheat pasture.

Table 2. Sources and amount of variation and level of significance obtained for differences among least square means of flow of nutrients to the duodenum, as estimated from ytterbium (Yb) or chromium (Cr) as single markers (n=4).

		Duodenal Flow			
		Organic Matter		Nitrogen	
Item	Marker	lb/day	% intake	g/day	% intake
C.V.[1]	Yb	9.22	9.99	8.53	10.85
	Cr	13.84	15.09	14.21	17.88
R-sq[2]	Yb	.89	.94	.75	.96
	Cr	.56	.76	.82	.84
TRT[3]	Yb	.51	.02	.26	.02
	Cr	.27	.05	.12	.06
PER[4]	Yb	.01	.01	.05	.01
	Cr	.35	.03	.01	.01

[1]C.V. = Coefficient of variation.
[2]R-sq = Coefficient of determination.
[3]TRT = With or without lasalocid.
[4]PER = Immature vs mature forage.

Literature Cited

Mader et al. 1984. Comparison of forage labeling techniques for conducting passage rate studies. J. Anim. Sci. 58:208.