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P.A. Momont
South Dakota State University

R.J. Pruitt
South Dakota State University

R.J. Emerick
South Dakota State University

R.H. Pritchard
South Dakota State University

EVALUATION OF CONTROLLED RELEASE CHROMIC OXIDE BOLUSES AND ALKALINE HYDROGEN PEROXIDE LIGNIN AS MARKERS TO DETERMINE INTAKE OF COWS FED MATURE PRAIRIE HAY

P. A. Momont[1], R. J. Pruitt[2], R. J. Emerick[3] and R. H. Pritchard[2]
Departments of Animal and Range Sciences and Chemistry

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Summary

A digestion trial involving 8 mature cows fed mature prairie hay ad libitum was conducted to determine the validity of controlled release chromic oxide (Cr) and alkaline hydrogen peroxide lignin (APL) as markers for prediction of forage intake by the fecal output (FO)/indigestibility ratio technique. Seven days after oral administration of Cr boluses, total FO was collected daily, weighed and sampled. Rectal fecal grab samples were collected at 10:00 a.m. each day and at 4-hour intervals on day 4 of collections. Mean fecal Cr output based on total fecal collections was 1,662 mg Cr/day compared to a manufacturer's suggested value of 1,505 mg Cr/day. Based on forage and fecal APL levels, mean fecal APL recovery was 95.9%. Increasing the number of days that grab samples were composited raised R^2 values between actual FO and dry matter digestibility (DMD) and those predicted using fecal Cr and APL concentration (R^2 = .56, .70, .77, .79 and .82; .27, .55, .61, .67 and .70 for 1- to 5-day composites for FO and DMD, respectively). With samples composited over the entire 5-day collection period, predicted FO, (DMD) and dry matter intake (DMI) were similar (paired t-test) to actual values. Fecal grab samples and total fecal collection samples, composited over 5 days, provided a similar relationship (R^2 = .71) between actual and predicted DMI. Fecal Cr and APL concentrations were not affected by sampling time of day. Results from this study indicate that grab samples collected once daily and composited over 5 consecutive days can be used to predict FO when controlled release chromic oxide boluses are used. While accuracy of DMD estimations was not as high as that of FO, APL was nearly 100% recoverable and resulted in reliable predictions of DMD and DMI.

(Key Words: Markers, Chromic Oxide, Alkaline Hydrogen Peroxide Lignin, Intake, Digestibility.)

Introduction

Effective research procedures to determine forage digestibility and intake of grazing animals would contribute greatly to understanding the effects of management and supplementation practices on animal performance. To estimate dry matter intake (DMI), the following equation can be used: DMI = Fecal output (FO)/(1-digestibility). More precise estimations of FO and DMD have been made with recently developed internal (alkaline hydrogen peroxide lignin, APL) and external (controlled release chromic oxide, Cr) marker procedures. The objectives of this study were to evaluate APL and Cr for estimating FO, DMD and DMI of cows consuming mature prairie hay.

Materials and Methods

Eight mature cows (mean weight = 1,389 lb ± 34) fed mature prairie hay ad libitum were maintained in individual pens for a 5-day DMI measurement and fecal collection period. On day 7 of a 14-day intake stabilizing period preceding fecal collections, controlled release chromic oxide (Cr) boluses (Captec Chrome, NuFarm Industries, Aukland, New Zealand) were orally administered. Boluses were designed to release 1,505 mg Cr/day (Manufacturer's test completion date = 12/12/88, batch #81122-8). Prairie hay was fed twice daily at a level approximately 10% above ad libitum intake. Composition of the mature prairie hay is listed in Table 1. Individual orts were weighed and refed each day. Final orts were weighed and sampled at the end of the trial. Total fecal collections were accomplished by scraping concrete floors of each pen a minimum of four times a day. Daily total FO was weighed, mixed and sampled. Rectal fecal grab samples were taken at 10 a.m. each day and at 4-hour intervals on day 4 of collections. All fecal samples were weighed and frozen (-30 °C) for later analytical

[1]Graduate Assistant.
[2]Associate Professor.
[3]Professor.

TABLE 1. CHEMICAL AND SPECIES COMPOSITION OF PRAIRIE HAY CONSUMED BY COWS[a]

Item	Percent
Dry matter	84.1
Crude protein	5.8
Neutral detergent fiber	70.2
Acid detergent fiber	39.0
Alkaline hydrogen peroxide lignin	1.57
Calcium	.40
Phosphorus	.11
Sulfur	.10
Western wheatgrass (*Agropyron smithii*)[b]	65.0 ± 10.0
Japanese brome (*Bromus japonicus*)[b]	35.0 ± 11.0
Unidentified forage[b]	2.0 ± 3.0

[a] Percent dry matter basis.
[b] Mean and SD from 15 samples.

procedures. Feed, final orts, and fecal samples were oven dried at 60 °C and ground (1-mm screen). Fecal Cr concentrations were determined by a microdigestion-oxidation procedure and flame atomic absorption spectrophotometry. Prairie hay and fecal APL concentrations were analyzed by an alkaline peroxide predigestion followed by standard lignin procedures. Equations used in the process of estimating DMI are listed in Table 2.

Predicted minus actual values (FO, DMD and DMI) were generated as dependent variables. Coefficients of determination (R^2) were determined by regressing predicted over actual FO, DMD and DMI values using General Linear Model procedures of the Statistical Analysis System. These regressions were conducted by progressively compositing data from collection days 1 to 5 for fecal grab samples and total fecal collection samples. Predicted and actual values

TABLE 2. EQUATIONS USED WITH MARKER PROCEDURES IN PROCESS OF DRY MATTER INTAKE ESTIMATIONS[a]

Cr excretion rate, mg/day = (mg Cr/g fecal DM) x (g fecal DM output/day)

$$\text{Percent APL recovery} = \frac{(\text{percent fecal APL}) \times (\text{g fecal DM/day})}{(\text{percent dietary APL})^{b} \times (\text{g DMI/day})}$$

$$\text{Predicted fecal DM output g/day} = \frac{(\text{mean Cr excretion rate, mg/day})^{c}}{(\text{mg Cr/g fecal DM})}$$

$$\text{Predicted DM indigestibility} = \frac{(\text{percent dietary APL})}{(\text{percent fecal APL})}$$

$$\text{Predicted DMI} = \frac{(\text{predicted fecal DM output, g/day})}{(\text{predicted DM indigestibility})}$$

[a] Cr = Cr_2O_3, APL = alkaline peroxide lignin.
[b] Mean dietary APL = 1.57%.
[c] Mean excretion rate = 1,662 mg Cr/day.

were also compared using Means procedure with the paired t-test option (SAS, 1985). Fecal APL and Cr concentrations were regressed over sampling time of day (quartic to linear responses were tested). Sampling time was also used as a discrete independent variable to generate least squares means. Mean separation was accomplished using the Least Significant Difference procedure.

Results and Discussion

Mean Cr excretion rate from cows was 1,662 mg Cr/d ± 63 with a range from 1487 to 2,020 mg Cr/day. Manufacturer's reported release rate for this allotment of boluses was 1,505 mg Cr/day. Mean APL fecal recovery from cows was 95.9% ± 3.2 ranging from 81 to 106%.

No diurnal variation of fecal Cr or APL excretion was detected (Figure 1). Based on polynomial regression, sampling time of day did not affect (P>.69, quartic to linear responses tested) fecal Cr or APL concentrations. Mean fecal Cr concentration for the eight cows on day 4 was 42.2 µg/g and fecal Cr concentration at each 4-hour interval was not affected by sampling time of day (P=.97). Mean fecal APL concentration was 4.9% ± .24 and fecal APL did not differ over sampling time (P=.94).

Accuracy of predicting FO, DMD and DMI was improved by increasing the number of days that samples were collected and composited (Figures 2 and 3). The R^2 values represent the percent of the variation associated with actual FO, DMD or DMI that can be accounted for by their respective predicted values. Increases in R^2 values between predicted and actual FO, DMD and DMI diminished with additional sampling days.

Predicted FO from Cr concentrations were closely related to actual FO. Using 5-day composited samples, high R^2 values for both fecal grab samples and samples from total collections were determined (.82 and .85, respectively). Lower R^2 values between actual DMD and DMD predicted from APL concentrations (R^2 = .70 and .65., for 5-day fecal grab and subsamples) resulted in reduced accuracy of DMI estimations (R^2 = .71 and .71 for grab and total collection samples). Predicted minus actual FO, DMD and DMI values were not different from zero (Table 3).

These results indicate that grab samples collected once daily on 5 consecutive days can be composited and used with high accuracy to predict FO when controlled release Cr boluses are used. This technique has the potential to reduce animal handling time, stress and disruption of animal grazing patterns compared to twice daily administration of Cr gelatin capsules. While mean recovery of APL in the feces was nearly 100%, accuracy of digestibility estimates using APL as an internal marker was not as high and influenced predictions of DMI.

TABLE 3. RELATIONSHIPS BETWEEN ACTUAL AND PREDICTED FECAL OUTPUT, APPARENT DRY MATTER DIGESTIBILITY AND DRY MATTER INTAKE

Item	Actual	Predicted	Difference[a]	Probability[b]
Fecal grab samples				
FO, lb	9.3	9.6	.3 ± .4	.49
DMD, %	58.9	56.5	-2.4 ± 1.8	.21
DMI, lb	22.7	22.0	-.6 ± .9	.49
Daily fecal subsamples				
FO, lb	10.0	9.9	-.03 ± .07	.94
DMD, %	56.0	55.5	-.5 ± 2.2	.85
DMI, lb	22.7	22.3	-.3 ± .7	.63

[a] Predicted minus actual and SEM.
[b] Probability that mean difference is different from zero.

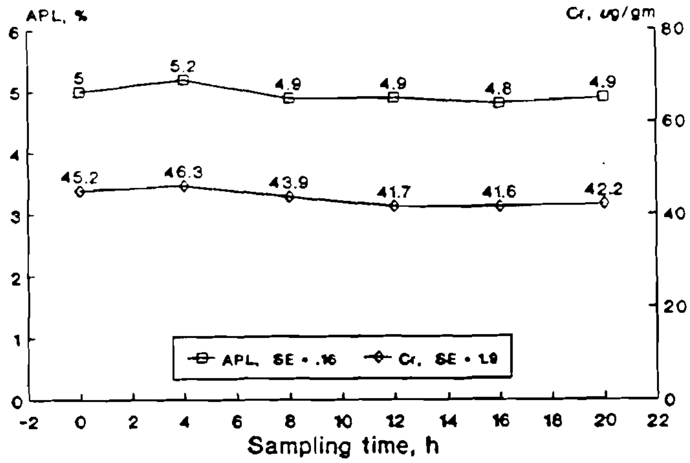

Figure 1. Effect of sampling time on fecal chromic oxide and alkaline hydrogen peroxide lignin concentrations.

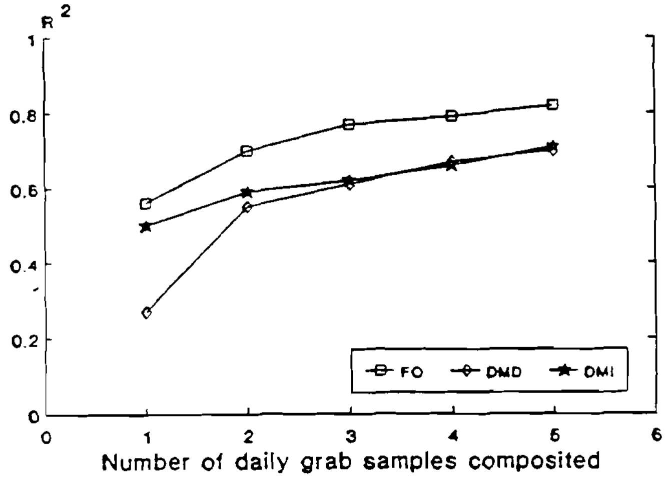

Figure 2. Effect of number of daily fecal grab samples composited on accuracy of FO, DMD and DMI predictions.

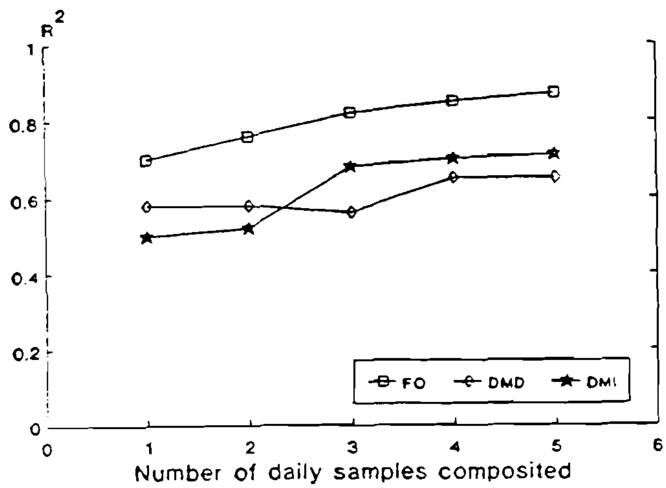

Figure 3. Effect of number of daily fecal samples composited from total collections on FO, DMD and DMI predictions.