South Dakota State University
Department of Animal Science

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Cow/Calf

Fecal near infrared reflectance spectroscopy (NIRS) and the nutrition balance analyzer (NUTBAL) case study in South Dakota

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Objective

The objective of this study was to compare fecal near infrared reflectance spectroscopy (NIRS) and the nutrition balance analyzer (NUTBAL) results with diet samples and cattle performance to determine if fecal NIRS and NUTBAL can accurately predict forage quality and cattle performance in South Dakota.

Study Description

In 2013-2014, 7 ruminally cannulated steers were used to collect diet and fecal samples. Fecal samples were analyzed using fecal NIRS at the Grazing Animal Nutrition Laboratory (GANLAB) in Temple, TX, while the diet samples were analyzed using wet chemistry methods at the Ruminant Nutrition Laboratory at North Dakota State University (NDSU). Performance results from NUTBAL were compared to actual performance of a contemporary group of steers grazing the same pastures where the diet and fecal samples were collected.

Take home points

Following analysis, it was determined that fecal NIRS did not accurately predict crude protein (CP) and digestible organic matter (DOM) of South Dakota cattle diets. A 1:1 ratio did not exist for the regression analysis relating predicted to actual values for either CP or DOM. Additionally, the NUTBAL analysis for predicting animal performance consistently predicted lower ADG than was achieved by cattle grazing alongside the cannulated steers. These results are similar to other comparisons of NIRS/NUTBAL predictions to actual diets and cattle performance conducted in other states. As an alternative to fecal samples, producers can utilize body condition scoring and visual monitoring of fecal consistency to monitor nutritional status of beef cattle and make feed management recommendations.

Keywords: cattle, diet quality, fecal NIRS, forage, NUTBAL

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Abstract

Fecal near infrared reflectance spectroscopy (NIRS) and the nutrition balance analyzer (NUTBAL) system analysis are widely utilized in the Natural Resource Conservation Service Conservation Stewardship Program; however South Dakota producers enrolled in the program have questioned reliability of the results. In 2013-2014, 7 ruminally cannulated steers were used to collect diet and fecal samples. Fecal samples were analyzed using fecal NIRS at the Grazing Animal Nutrition Laboratory (GANLAB) in Temple, TX, while the diet samples were analyzed using wet chemistry methods at the Ruminant Nutrition Laboratory at North Dakota State University (NDSU). Following analysis, it was determined that fecal NIRS did not accurately predict crude protein (CP) and digestible organic matter (DOM) of South Dakota cattle diets. A 1:1 ratio did not exist for the regression analysis relating predicted to actual values for either CP or DOM. Additionally, the NUTBAL analysis for predicting animal performance consistently predicted lower ADG than was achieved by cattle grazing alongside the cannulated steers. These results are similar to other comparisons of NIRS/NUTBAL predictions to actual diets and cattle performance conducted in other states.

Introduction

The use of fecal near infrared reflectance spectroscopy (NIRS) and the nutrition balance analyzer (NUTBAL) system analysis is widely utilized in the Natural Resource Conservation Service (NRCS) Conservation Stewardship Program (CSP). In theory, if a producer utilizes this tool they collect fecal samples, have them analyzed and then evaluate whether or not supplementation is needed to meet cattle performance goals. The concern that encouraged the development of studies in South Dakota came when producers enrolled in the program questioned reliability of results.

For example, in 2012, producers from western South Dakota enrolled in this CSP enhancement received reports from the Grazing Animal Nutrition Lab (GANLAB) in Temple, Texas and questioned the accuracy of the predictions of diet quality and cattle performance. They requested assistance in interpreting results, and NRCS referred them to SDSU Extension. This process raised additional questions regarding prediction accuracy and whether the program works in South Dakota. In some cases, the program predicted weight loss in excess of 3 lbs. per head per day, but producers were not observing this loss when monitoring body condition. Due to concerns South Dakota producers had with predicted performance of their animals and the extreme variation in results they received, a case study project was conducted to evaluate the efficacy of the fecal NIRS and NUTBAL system in South Dakota. This 2-year project analyzed how well the fecal NIRS predictions compared to actual dietary nutrient content using ruminally cannulated animals. A comparison was made of predicted performance by NUTBAL and actual steer performance. This project was conducted on native rangeland in north-central South Dakota during the summers of 2013 and 2014 (Olson et al., 2016, Harty and Olson, 2018)

Experimental Procedures

Seven ruminally cannulated steers were used to collect diet samples to determine nutrient content (Lesperance et al., 1960; Olson, 1991). Grazing ruminants are highly selective therefore their diets are always nutritionally superior to clipped forage samples. Thus, diet sample collection using cannulated animals is considered the best research tool available for evaluating grazing livestock diets. This study provided an opportunity to compare fecal NIRS predictions of nutrient content to actual diets. Fecal samples were collected from the rectum of cannulated steers at the same time diet samples were collected. Diet and fecal sampling was conducted monthly beginning in June and ending in August each year. Diet and fecal samples were frozen immediately after collection. Diet samples were analyzed at the Ruminant Nutrition Laboratory at NDSU to determine CP content and in vitro organic matter digestibility (IVOMD, an estimate of energy content of the diet that is synonymous with DOM). Fecal samples were sent to the GANLAB in Texas for fecal NIRS analysis and generation of the NUTBAL report.

Results and Discussion

To determine if fecal NIRS and NUTBAL provided an accurate and reliable prediction of actual CP, IVOMD/DOM, and steer average daily gain (ADG), regression analysis was used to statistically evaluate the predictive relationship between the results from the fecal NIRS and NUTBAL report with actual diets and steer performance. Within each linear regression, the r^2 value was evaluated to determine how much of the variation in the relationship between fecal NIRS predictions and actual values could be explained. The r^2 value can range from 0 to 1, with 0 meaning there is no relationship and 1 meaning there is a perfect fit. For fecal NIRS predictions to be considered accurate and useful, a 1:1 relationship between predicted and actual values should exist. The regression line should have a slope of 1 (i.e. the actual value and the fecal NIRS prediction would be the same without adjustment) and the intercept of the regression line should be 0 (i.e. 0 should be predicted when 0 is the actual value). A hypothesis test was constructed to test if slope was different from one. The test of the significance of the intercept estimate was used to evaluate if it was different from zero.

Crude protein. The relationship between predicted and actual CP was statistically similar across years ($P > 0.05$), so all data was combined into one regression analysis (Figure 1). This means the predictive relationship had consistent value across years and should have similar predictive value in the future. The r^2 for the regression equation was 0.78, meaning 78% of the variation in actual dietary CP could be explained by the predicted fecal NIRS values. The predictive relationship is reasonably strong. The regression slope was 0.70, which was not statistically similar to 1 ($P < 0.001$). The intercept was 4.1, which was not statistically similar to 0 ($P < 0.001$). Thus, there was not a 1:1 relationship between actual and predicted values for CP. For example, if fecal NIRS predicts dietary CP of 9.5%, one cannot assume that equates to actual dietary CP of 9.5%. In this example, the actual CP value from the diet sample would be 10.76% after adjusting the predicted value using the regression equation. Thus, any other attempted recommendations would be cumbersome because they would require applying the regression equation to the predicted values to obtain accurate estimates of actual dietary CP. For the remaining NUTBAL predictions and nutritional management recommendations to be valid, this regression relationship would need to be 1:1.

In vitro organic matter digestibility. The regression relationship for IVOMD was not consistent across years (i.e. year interacted with the prediction of IVOMD [$P = 0.02$], indicating the regression relationship for 2013 was different from the 2014 relationship. Because results were not consistent across years, the capacity to confidently use the equations in future years is limited. Differing regression relationships are contrasted in Figure 2. For 2013, the r^2 value indicated that the model explained about 56% of the variation, which was less than desirable. However, for 2013, the intercept (-7.7) was statistically similar to 0 (P =0.60) and the slope (1.17) was statistically similar to 1 ($P = 0.49$), approaching a 1:1 predictive relationship. In 2014, the r^2 value of 0.85 was greater, but the intercept (-73.1) was substantially different from 0 ($P < 0.001$) and the slope (2.17) was substantially different from 1 ($P < 0.001$). Overall, fecal NIRS did not consistently nor adequately predict IVOMD in a 1:1 relationship.

Steer performance results were much like those reported by producers: negative gain was predicted for conditions where cattle were actually in a positive plane of nutrition and gaining weight (Table 1). In particular, in August 2013, NUTBAL predicted average daily weight change that ranged from -3.24 lb. to +2.48 lb. (average was -1.5 lb.) across the 7 cannulated steers. Negative gains were predicted for 6 of the 7 head. Weight loss was predicted despite fecal NIRS predictions for the same steers of CP and DOM that were great enough to support weight gain. Actual ADG of the contemporary group of yearling steers that grazed the pastures where diet and fecal samples were collected was 1.48 lb. during August 2013.This was 3 lb. more than the average of the NUTBAL predictions. Although NUTBAL predictions of ADG for the remainder of 2013 and all of 2014 were for positive ADG, they were different from actual ADG. Because of these obvious differences, statistical analysis was not attempted because the lack of a relationship between predicted and actual performance was so great.

Implications

Reliability of results from fecal NIRS is limited, especially in the Northern Great Plains. Based on the results, fecal NIRS was not capable of predicting forage quality in South Dakota. There was a lack of consistency of results for CP, TDN and cattle performance that eliminated the possibility of developing an adjustment factor to apply to GANLAB reports. Under current conditions, the value of this tool to assist in making management decisions based on diet quality and cattle performance is limited. If cattle producers are solely using NUTBAL for estimates of forage value, miscalculations for supplemental energy and protein requirements are likely and may result in the purchase of unnecessary supplements. As an alternative to fecal samples, producers can utilize body condition scoring and visual monitoring of fecal consistency to monitor nutritional status of beef cattle and make feed management recommendations (Harty, 2019).

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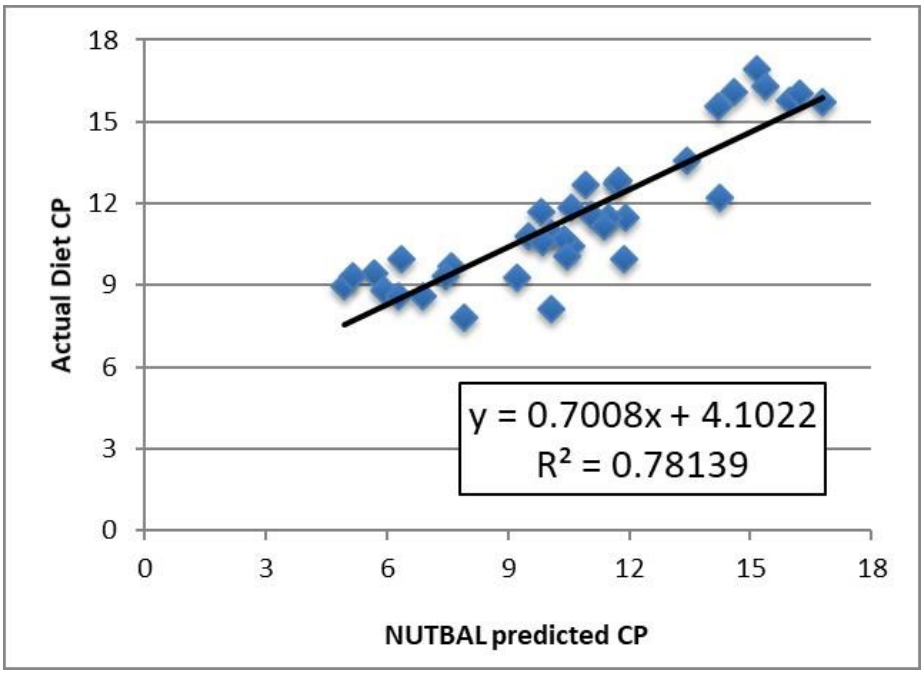

Figure 1. Regression of actual dietary crude protein on fecal NIRS prediction of dietary crude protein to validate ability of fecal NIRS to predict actual dietary crude protein. Coefficient of variation (r^2) estimates proportion of variation in actual values explained by predicted values. R^2 values range from 0 to 1 with those closer to 1 being better. The regression intercept should be 0 and slope should be 1 for a 1:1 relationship between predicted and actual values. Intercept and slope differ from 0 and 1 ($P < 0.05$), respectively.

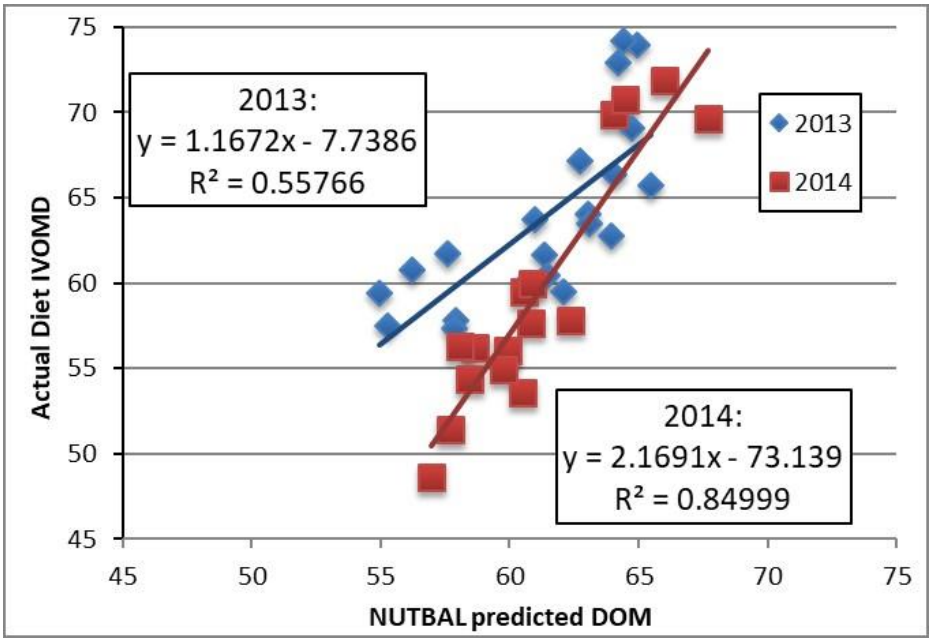

Figure 2. Regression of actual dietary in vitro organic matter digestibility (IVOMD) on fecal NIRS prediction of dietary digestible organic matter (DOM) to validate ability of fecal NIRS to predict actual dietary IVOMD. Regression relationships differed among years ($P < 0.05$). Coefficient of variation (r^2) estimates proportion of variation in actual values explained by predicted values. R^2 values range from 0 to 1 with those closer to 1 being better. The regression intercept should be 0 and slope should be 1 for a 1:1 relationship between predicted and actual values. Intercept and slope were similar to 0 and 1 ($P > 0.05$), respectively, in 2013, but differed from 0 and 1 ($P < 0.05$) in 2014.

Table 1.

Year	Month	Predicted ADG, lb	Actual ADG, lb
2013	June	2.21	2.50
2013	August	-1.46	1.48
2014	June	2.84	2.22
2014	August	1.20	1.83