Proceedings, The Range Beef Cow Symposium XXVI
November 18, 19 and 20 2019, Mitchell, Nebraska

Cowpieology: Does NUTBAL work?

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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, when 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. South Dakota and Nebraska researchers developed studies when producers enrolled in the program questioned the reliability of the results.

Beginning in 2012, the same scenario played out across western South Dakota and Nebraska. Producers enrolled in this 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 from NRCS and Extension staff. This evaluation raised additional questions regarding prediction accuracy and how well the program works with South Dakota and Nebraska forages. In some cases, the program was predicting weight loss in excess of 3 lbs. per head per day, but producers were not observing this loss when monitoring body condition.

Due to the concern South Dakota producers had in trusting the predicted performance of their animals as well as the extreme variation in results they were receiving; a case study project was conducted to evaluate the efficacy of the fecal NIRS and NUTBAL system in South Dakota. This was a 2-year project to analyze how well the fecal NIRS predictions compared to actual dietary nutrient content using ruminally cannulated animals. A comparison was also made of predicted performance by the NUTBAL program 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)

In Nebraska, a three-year study was conducted to compare quality estimations from forage samples collected with esophageal fistulated animals, hand clipping, and fecal samples from cows grazing Sandhills rangeland and meadows. This study was conducted at Gudmundsen Sandhills Lab near Whitman, NE in 2015, 2016 and 2017 (Johnston et al., 2019).

Methods

South Dakota (Harty and Olson, 2018). 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 so their diets are always nutritionally superior to

clipped forage samples. Therefore, diet sample collection using cannulated animals is considered the best research tool available for evaluating grazing livestock diets. All steers were cannulated as yearlings in 2013 and used in both years. 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 being collected. 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.

Nebraska (Johnston et al., 2019). In this study, during the months of July, September and November of 2015, 2016 and 2017, fecal samples were collected directly from 12 cows grazing meadow and 12 cows grazing upland range. The cows ranged from three to nine years of age. Three esophogeally fistulated cows grazed the upland pastures and meadows and diet samples were collected at the same time fecal samples were collected from the cows. In addition, forage samples were clipped by hand on upland range, utilizing a subjective approach, where the person collecting attempted to select forage in a way that mimicked what cattle were observed to be selecting. This method of estimating forage quality can underestimate the quality of the diet that cattle are selecting on low quality forage.

After samples were collected, forage quality for samples from esophageally fistulated cows and hand plucked samples were evaluated for crude protein. Energy or total digestible nutrients (TDN) were analyzed utilizing an ADF analysis for clipped samples, while the esophageal samples were analyzed utilizing in vitro digestibility techniques. Fecal samples were evaluated for crude protein and energy utilizing the fecal NIRS and NUTBAL program.

Results

South Dakota. 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).

Crude protein. The relationship between predicted and actual CP was similar across years, meaning that all data could be combined into one regression analysis (Figure 1). This

outcome 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 and is reasonably strong. The regression slope was 0.70, which was not statistically similar to 1. The intercept was 4.1, which was not statistically similar to 0. 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, however using this equation would be cumbersome to predict values to obtain accurate estimates of actual dietary CP. For predictions and nutritional management recommendations to be valid, this regression relationship would need to be 1:1.

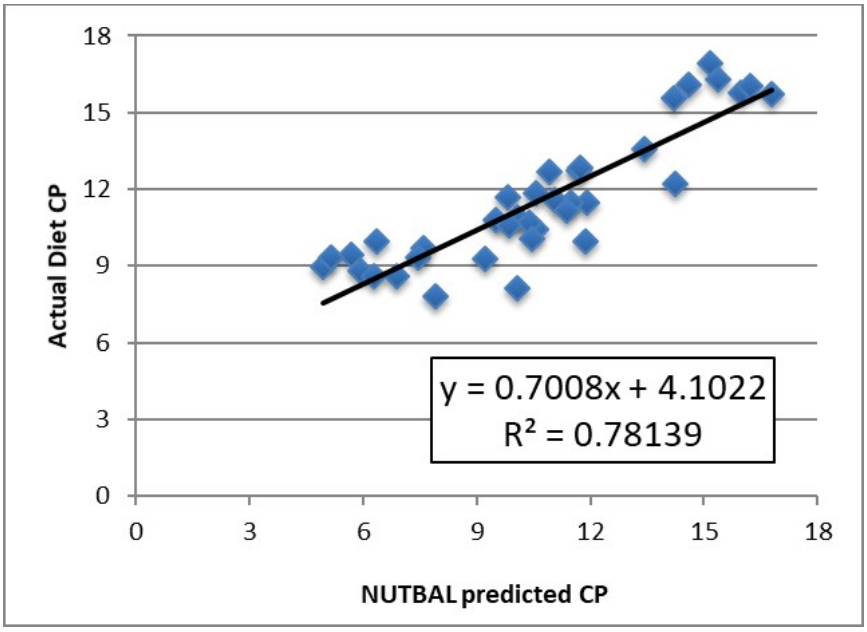

Figure 1. Regression of actual dietary crude protein on fecal NIRS prediction of dietary crude protein to validate ability of fecal NIRS to predict actual dietary crude protein. Coefficient of variation (r^2) estimates proportion of variation in actual values explained by predicted values. R^2 values 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.

In vitro organic matter digestibility. The regression relationship for IVOMD was not consistent across years (i.e. year interacted with the prediction of IVOMD), 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 Fig. 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 and the slope (1.17) was statistically similar to 1, 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 and the slope

(2.17) was substantially different from 1. Overall, fecal NIRS did not consistently nor adequately predict IVOMD in a 1:1 relationship.

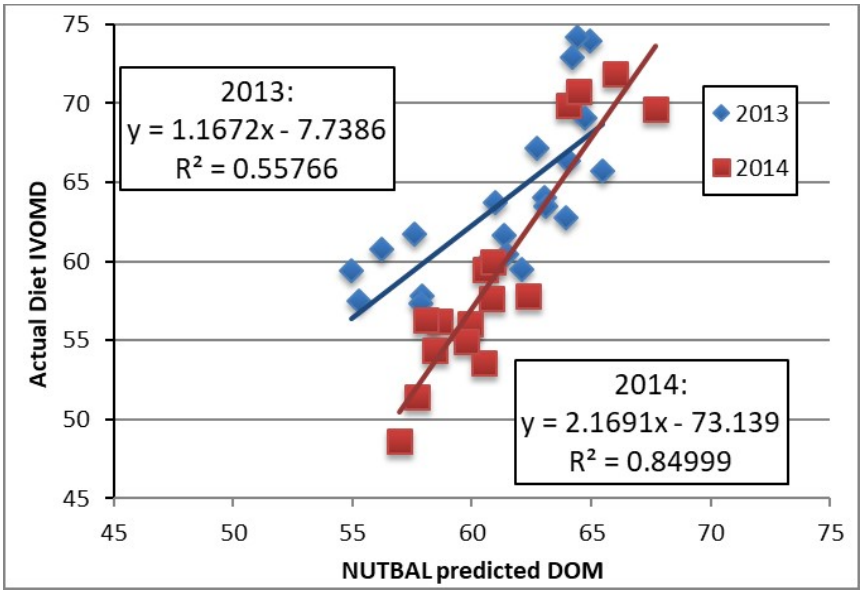

Figure 2. Regression of actual dietary in vitro organic matter digestibility (IVOMD) on fecal NIRS prediction of dietary digestible organic matter (DOM) to validate ability of fecal NIRS to predict actual dietary IVOMD. Regression relationships differed among years ($P < 0.05$). Coefficient of variation (r2) 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.

Results with steer performance 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 that diet and fecal samples were collected from. 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 the 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.

Table 1. Average daily gain (ADG) predicted by NUTBAL compared to actual ADG of the contemporary group of steers used in this study for each month of sampling where diet samples, fecal samples, and weights of steers were collected.

Year	Month	Predicted ADG, lb	Actual ADG, lb
2013	June	2.21	2.50

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

Nebraska. Like the South Dakota study, Nebraska results were inconsistent across forage type. Overall, considering both forage types, CP was slightly underestimated and TDN was consistently over estimated in the fecal NIRS model, ranging from 2.5-7.1 percentage points (Table 2). Decline in diet quality as forage matured over time was not fully captured through NIRS/NUTBAL analysis.

Table 2. Comparison of actual crude protein (CP) and total digestible nutrients (TDN) of diet samples to fecal NIRS predictions on upland range and subirrigated meadows in the Nebraska Sandhills (from Johnston et al., 2019). DOM reported by GANLAB was converted to TDN by multiplying DOM by 1.06. Fecal NIRS prediction differs from actual nutrient content when $P < 0.05$.

Upland				
Item	**Diet**	**NIRS**	**SE**	**P-Value**
CP				
Jul	8.0	8.0	0.3	0.99
Sep	7.1	5.2	0.3	<0.01
Nov	5.4	5.2	0.3	0.92
TDN*				
Jul	56.6	65.8	1.0	<0.01
Sep	46.2	64.4	1.0	<0.01
Nov	44.3	62.4	1.0	<0.01
Subirrigated Meadows				
CP				
Jul	10.2	9.4	0.3	0.05
Sep	9.3	9.3	0.3	0.99
Nov	8.1	5.0	0.3	<0.01
TDN				
Jul	58.9	60.6	1.2	0.17
Sep	51.2	60.3	1.2	<0.01
Nov	43.9	55.8	1.2	<0.01

The NUTBAL analysis of crude protein and energy values from fecal samples differed significantly from the nutrient analysis of esophageally fistulated and hand-clipped forage samples. This study was consistent with other studies that showed diets selected by cattle tend to be higher in quality than those selected by hand from the same location.

The NUTBAL analysis of crude protein and energy from fecal samples on Sandhills range and meadows differed from the wet chemistry analysis from esophageally fistulated and hand-clipped forage samples. These differences were significant and would have resulted in miscalculations for supplemental feeding of protein and energy. Currently, for Sandhills rangeland and meadows, NUTBAL analysis does not consistently, accurately reflect forage quality. Producers solely utilizing this analysis to make supplementation decisions would likely miscalculate the energy and protein needed by cattle to meet performance goals.

Conclusion

Based on the results from the South Dakota and Nebraska projects, fecal NIRS was not capable of predicting forage quality in South Dakota or Nebraska forages. 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, reducing profitability of an operation and potentially creating economic hardship. Feed management recommendations based on fecal NIRS/NUTBAL are often unnecessary and would be costly if followed.

Implication

Reliability of results from fecal NIRS is limited, especially in the Northern Great Plains. As an alternative to fecal samples, producer 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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