SITE, EXTENT, AND RATE OF CORN SILAGE DIGESTION IN DAIRY CATTLE

D.A. Sapienza, Ph.D. Pioneer Hi-Bred International, Inc.

The Seventh Revised Edition of the Nutrient Requirements of Dairy Cattle (NRC, 2001) uses a summative approach to calculate TDN1x, which is a necessary term for calculating NEL1x in the NRC approach. This approach applies the equations of Weiss and coworkers (Weiss et al, 1992). Our laboratory investigated the suitability of different analytical techniques to quantify inputs to the individual equations (2-4a to 2-4e, Dairy NRC p14). We paid particular attention to the measurements associated with measuring truly digestible NFC (tdNFC) and truly digestible NDF (tdNDF) in samples of whole-plant corn. Our approach was to use in-vitro and in-situ measurements of extent and rate of dry matter, starch and NDF digestion. We also calculated NEL using a regression equation based on ADF content (Schmid et al., 1976). ADF regression equations are a common way of calculating NEL in commercial forage laboratories (NFIA, personal communication)

Plant material was produced by growing ten hybrids in three locations and then harvesting each hybrid at seven different maturites. The maturity range was from approximately 25% dry matter (whole plant) to grain maturity; with five of the maturities in the silage harvest window. Twenty individual hybrid-by-maturity selections were chosen for detailed analysis. The replicates were determined by reviewing the compositional data and all NIR spectra collected. The chemical and spectral diversity of the chosen plant material was compared to similar data collected from a national whole-plant corn forage-testing program that included about 1100 locations and about 500 different germplasm. The compositional data of the residue was used to develop a set of NIR calibration equations. The NIR calibrations are used to predict the % composition (dry matter, ash, starch and NDF) at individual time points important for calculating rate and extent of ruminal degradation of whole-plant corn forage.

The distribution of approximately 5,000 samples from our national testing program is given in Table 1. We focused on the distribution of starch and NDF in accordance with our objectives of evaluating tdNFC and tdNDF. Because there is a relationship between starch and NDF content, the samples analyzed for the reported evaluation included high and low starch and NDF concentrations and, in aggregate, spanned both of the national ranges.

Proceedings of the 36th Annual Pacific Northwest Animal Nutrition Conference. October 9-11, 2001. Boise, ID, pp. 15-18.

Table 1. Percentage of National Samples in Each Range for Starch and NDF				
Starch (% DMB)			**NDF (% DMB)**	
Range	**Percentage**		**Range**	**Percentage**
0 to 15	2		0 to 34	1
15 to 20	3		34 to 38	7
20 to 25	10		38 to 42	31
25 to 30	22		42 to 46	43
30 to 35	31		46 to 50	13
35 to 40	23		50 to 55	4
40 to 45	8		> 55	1
> 45	1			

An in-vitro system was used generated gas production data and to produce residue. Approximately 300mg were weighed into 250ml serum vials (ratio of 1.2mg per ml and not to exceed 2mg per ml). Then 6ml of rumen fluid were collected pre-prandial, strained, gassed with CO2 and diluted (6ml with 24ml) Van Soest buffer. All the donor steers were fed once daily at the level of 50g DM/kg BW $^{0.75}$ a standardized whole-plant corn silage based diet with hay (CP = 13.3; NDF = 38.3% DM). The in-vitro system automatically measured gas production every 20 minutes over a 30-hour time course. Plant residue was collected, stabilized and transported to a laboratory to determine DM, ash, fiber and starch content.

An in-situ system used, macro-bags (20x25cm) with a pore size of 40μm were prepared by sealing sufficient plant material to achieve 13mg DM/cm^2 surface area. Macro-bags were pre-soaked in cold water and inserted immediately pre-prandial to reside just below the ruminal fiber mat. Incubation times were executed individually with two replicate bags per sample per time point per each of four animals. Each bag was recovered at the predetermined incubation time and dried (55°C) to a constant weight. The residues were composited by incubation time within animal, ground, and analyzed for DM, ash, starch and fiber. The animals are fed the same diet as described for the in-vitro donor animals.

The residue and gas data were analyzed by curve-fitting models to determine, for each constituent, the quantity of instantly available material, the lag time, the rate and amount of the constituent degraded at a specific rate and the extent of the degradation of the constituent. A dual-pool logistic model was fit to the gas-production data using a nonlinear least

squares algorithm. The lag times from two pools were used as estimates of parameters in an exponential decay model to estimate rates of digestion (K_d). All of the computer models were applied to data that was checked for outliers by the Loess regression (Cleveland and Devlin, 1988).

The analytical values measured in our laboratory were used as inputs in the calculation of NEL by using a summative approach and by ADF regression as referenced above. The results are shown in Table 2.

Table 2 and Figure 2. NEL Calculated Using a Summative Approach (NRC) and ADF Regression

Range	NEL_{NRC}	NEL_{ADF}
% Starch DMB		
0 to 15	0.515	0.711
15 to 20	0.576	0.706
20 to 25	0.613	0.697
25 to 30	0.669	0.744
30 to 35	0.764	0.767
35 to 40	0.801	0.780
40 to 45	0.799	0.808

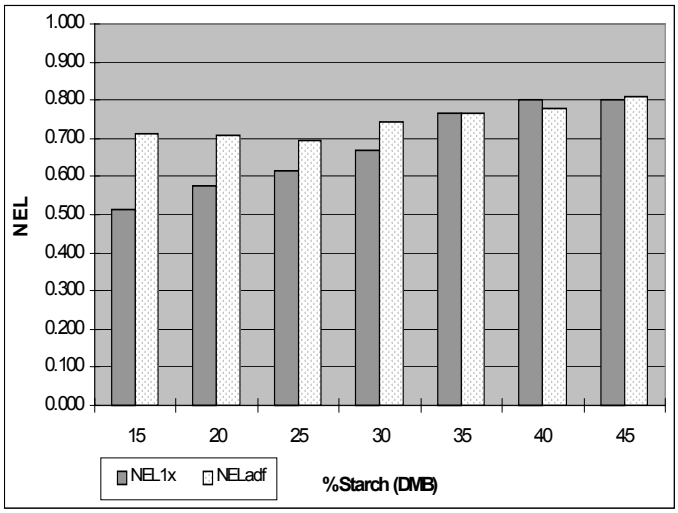

Table and Figure 2 show the comparison between the two methods of calculating NEL. The greatest diversion between the two methods occurs when starch concentration is at or below 30% (DMB). This situation occurred in about 37% of the sample population we studied in a year of typical rainfall. It would be more common in a drought year. Under growing or harvesting conditions that could limit starch concentration, it may be possible to overestimate the NEL content of whole-plant corn by applying an ADF regression equation and the summative approach may be more indicative of the NEL level in whole-plant corn.

References:

Cleveland, W.S., and S.J. Devlin. 1988. Locally weighted regression: An approach to regression analysis by local fitting. *J. Am. Statist. Assoc.* 83:596.

Doane, P.H., and A.N. Pell, and P. Schofield. 1997. Neutral detergent solubles after preservation. *J. Anim. Sci*. 75:1140.

NRC. 2001. Nutrient Requirements of Dairy Cattle, Seventh Edition. The National Academy of Sciences.

Schmid, W.S., and co-workers. 1976. ADF and regression analysis in dairy cattle feeds. J. Agron. 68.403

Van Soest, P.J., and J.B. Robertson, and B.A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and nonstaarch polysaccharides in relation to animal nutrition. *J. Dairy Sci.* 74:3583.

Weiss, W.P., et al. 1992. A summative approach to calculating net energy. *J. Dairy Sci.* 75:3400.