Importance of Considering Rate of Passage When Determining Energy Content of Forages for High Producing Animals

Dan J. Undersander
University of Wisconsin-Madison

D. K. Combs
University of Wisconsin-Madison

Edgard P. Beyer

Marcello T. Rodrigues

ID # 09-48

IMPORTANCE OF CONSIDERING RATE OF PASSAGE WHEN DETERMINING ENERGY CONTENT OF FORAGES FOR HIGH PRODUCING ANIMALS

D.J. Undersander[1], D.K. Combs[2], Edgard P.Beyer[3], and Marcello T. Rodrigues[3]

[1] Department of Agronomy, University of Wisconsin, Madison, WI 53706

[2] Department of Animal Science, University of Wisconsin, Madison, WI 53706

[3] Former graduate students now at Valdivia, Chile and Viçosa MG Brasil 36570-000, respectively

Abstract

The objective of this study was to determine the effect of higher rates of passage and correspondingly lower rumen retention times on digestion of forages. One hundred and fifty samples of legumes, grasses and grass-legume mixtures were collected from farmer samples submitted to commercial forage testing laboratories and 32 samples of alfalfa at varying maturity were collected from research plots. In vitro digestions were performed for either 24 or 48 hours followed by neutral detergent analysis. Neither acid detergent fiber (ADF) nor neutral detergent fiber (NDF) predicted the standard 48-hour digestion very well (r^2 = -0.38 and B0.26, respectively). Similar results were noted for 24-hour digestion ((r^2 = -0.48 and B0.47, respectively). While the correlation was high between 24- and 48-hour digestions (r^2 = 0.86), individual samples showed considerable variation. It is recommended that digestion kinetics be considered with determining energy availability for forages for higher producing animals.

Keywords: Digestion, rumen turnover, rumen retention, digestion kinetics, ADF, NDF

Introduction

High producing livestock do not retain forages in their digestive tract as long as low producing livestock and therefore do not digest as much as the potentially available energy from the forage. Digestibility is defined as the product of retention time in the rumen and degradation characteristics of the forage (Forbes, 1995). Traditional estimates of energy availability are static models, either 48-hour digestion or fiber based on 48-hour digestion, and do not consider varying forage rates of digestion or increased rumen turnover for high producing animals. Further, regression equations from fiber are population specific and lack sensitivity (Weiss et al, 1992). The most common procedure to estimate in vitro forage degradation is using a defined end point of fermentation such as 48h or 72h (Waldo, 1970). The drawback of using this approach is that it represents a static model, so that digestibility is estimated assuming a fixed turnover rate. A 48h fermentation is frequently used to estimate digestion at maintenance level of intake. High producing cows have a much higher turnover rate than cows at maintenance, and values estimated by this approach overestimate values of digestibility of feedstuffs. The use of fiber digestion kinetics suggested by Waldo and Smith (1972) makes it possible to estimate digestibility by simulating different rates of passage. This paper reports digestion differences of forage evaluated at maintenance (48-hour digestion) and 4x maintenance (24-hour digestion)

Material and Methods

One hundred and fifty samples of legumes, grasses and grass-legume mixtures were collected from commercial forage testing laboratories and utilized in the study. Samples consisted of hay and silage hay. About two thirds were grass-legume mixtures with varying proportions and types of grasses. The predominant legume was alfalfa. Approximately one third

of the samples were perennial grass or oat (*Avena sativa)* silage. In addition, thirty-two samples of pure alfalfa harvested from research plots were added. Thus a total of 182 forage samples were utilized in this study.

Each forage sample was analyzed for dry matter by using the two-step total Dry Matter (DM) determination of wet samples with partial drying in a forced-air-drying oven prior to grinding. Forage samples were then ground in a Wiley mill (model 3; Arthur H. Thomas, Philadelphia, PA) to pass a 2 mm screen and reground in a Udy cyclone grinder to pass a 1 mm screen.

Samples representing the population of mixed forages used for in vitro studies were selected using NIRSystems[J] model 6500 from Foss Analytical, Inc. The selection of the subset of samples from the original population for laboratory analysis was based on spectral characteristics.

Absolute dry matter was calculated by drying at 100^{O} C for 24h. Organic matter (OM) was calculated by ashing samples at 550^{O} C for 12h (Undersander et al, 1993). Determination of amylase neutral detergent fiber (aNDF) was according to the procedure of Goering and Van Soest (1970) and modified by Undersander (1993) using 0.5 g of sodium sulfite anhydrous (Na_2SO_3) and 200 Fl of heat stable á-amylase (Sigma Chemical Co., St. Louis, MO). Also, 100 Fl added to 50 ml of NDF solution prior to boiling and the other 100 Fl into the crucible filled with hot water during filtering. Glass microfiber filters with 4.25 cm (Whatman International Ltd., Maidstone, Kent, England) were added to the bottom of the crucibles to aid filtering aNDF residues. Acid detergent fiber (ADF) was measured non-sequentially (Undersander, et al., 1993).

The in vitro technique used was a modification of the procedure described by Goering and Van Soest (1970). Samples were incubated for either 24 or 48h and residues analyzed for

neutral detergent fiber at each fermentation time. At approximately 7:30 a.m., rumen fluid was collected from a fistulated and lactating Holstein cow. The cow was fed once a day at 8:00 a.m. a total mixed diet containing (DM basis) 40% alfalfa silage (55% DM), 20% corn silage (40% DM), 28.2% cracked shelled corn, 10% soybean meal, 1.1% dicalcium phosphate, and 0.7% trace mineral salt, plus vitamins A, D and E.

Results and Discussion

The results first indicate that a single fiber estimate has a very low correlation with the digestion observed over the range of samples in the study (Fig 1.). In fact a linear regression of acid detergent fiber explained only 38% of the variation in digestibility observed at 48 hours. It is evident from these results that, while single variable regression equations have been developed to predict digestibility (Harlan, et al., 1991; Mertens, 1987; Undersander et al., 1993), most are developed on a relatively narrow range of forages and when used by commercial forage testing laboratories that analyze a broader range of forages, the equations should not be expected to predict digestibility with any great accuracy. Correlations of digestion with ADF were slightly higher for 24-hour digestion (r^2 = .48) but still unacceptably low for use in balancing rations of high producing animals.

Figure 2 shows a subset of the highest quality forages from the entire data set. The forages are ranked for dry matter digestion at 48 hr. The bottom portion of each bar is 24 hr digestion and the top portion is the additional digestion in the second 24 hour period. While the overall correlation between 24 hr and 48 hr digestion was high (r^2 = 0.86), it is apparent from figure 2 that vast differences exist among individual samples. These differences would not be observed when doing 48 hr digestions. Some of the differences are related to species differences

(e.g. higher grass content). However it is necessary to have procedures that will predict the differences in a robust manner across species. (Note that 66% of the samples submitted to commercial testing laboratories in the Midwestern United States are mixed grass and legume samples). However there are also differences within species that are significant. Some of this is due to harvesting practices but some may also be due to the species genotype and presents future breeding objectives for forage breeders.

The results presented here demonstrate the importance of determining forage digestion at different rates of passage to better relate energy availability in the forage to the animal being fed. This becomes more important as animals are producing and being fed significantly above maintenance. Development of full kinetic digestion curves on each forage is time consuming and expensive. However this can now be accomplished by near infrared reflectance spectroscopy on an accurate and cost effective basis.

References

Forbes, J.M. (1995). Voluntary food intake and diet selection in farm animals. CAB International. Oxon, UK.

Goering, H.K. and Van Soest. P.J. (1970). Forage fiber analyses (apparatus, reagents, procedures and some applications). Agric. Handbook No. 379. USDA-ARS., Washington, DC.

Harlan, D.W., Holter J.B. and Hayes H.H. (1991). Detergent fiber traits to predict productive energy of forages fed free choice to nonlactating dairy cattle. J. Dairy Sci. **74:** 1337

Mertens, D.R. (1987) Predicting intake and digestibility using mathematical models of ruminal function. J. Anim. Sci. **64:** 1548.

Undersander, D., Mertens D.R. and Thiex N. (1993). Forage Analyses Procedures. National

Forage Testing Assoc., Omaha, NE. (http://www.uwex.edu/ces/forage/nfta/index.htm)

Waldo, D.R. (1970) Factors influencing voluntary intake of forages. Page E1 *in* Proceedings of the National Conference on Forage Quality Evaluation and Utilization. Barnes, R.F. et al (eds), Lincoln, Ne.

Waldo, D.R. and Smith L.W. (1972). Model of cellulose disappearance from the rumen. J. Dairy Sci. **55:** 125.

Weiss, W.P., Conrad H.R. and Pierre N.R.St. (1992). A theoretically-based model for predicting total digestible nutrient values of forages and concentrates. Anim. Feed Sci. Technol. **39**: 95.

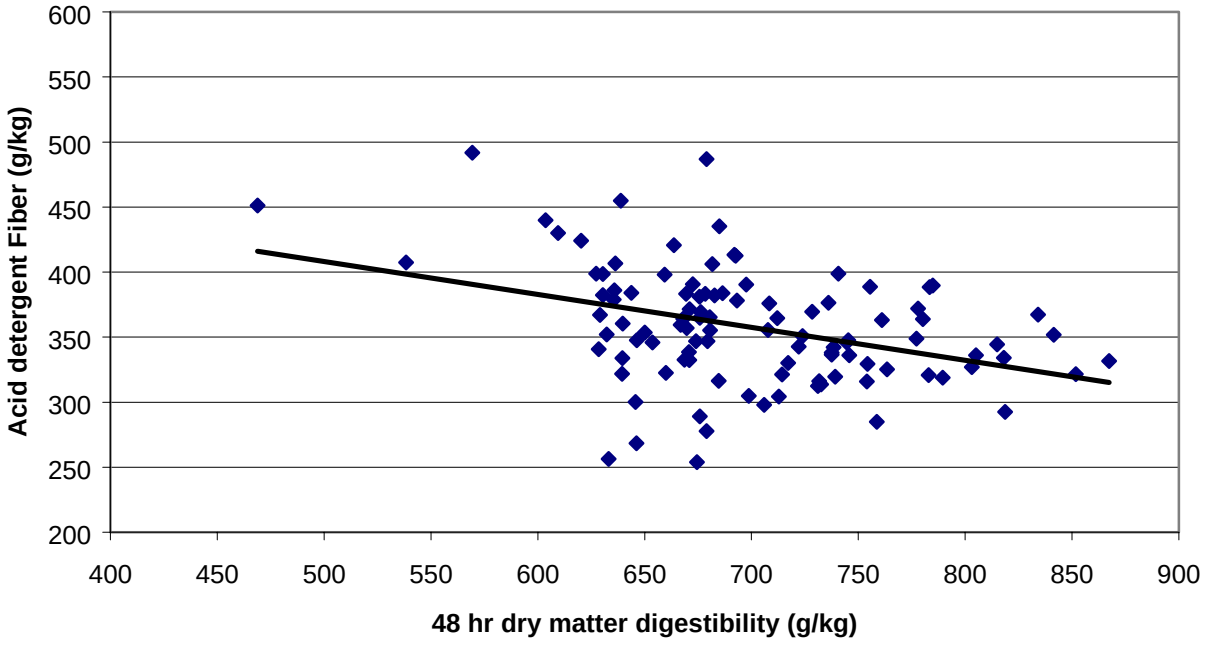

Figure 1 - Comparison of 48-hour digestibility to acid detergent fiber content of grass and legume samples.

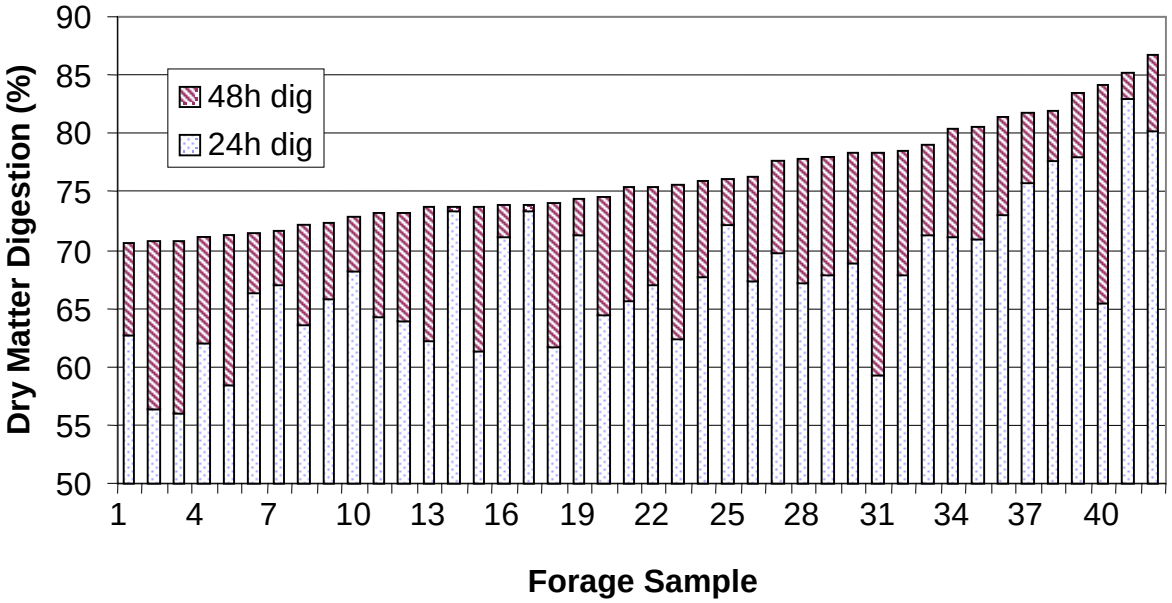

Figure 2 - Comparison of 24 and 48 hour digestion of high quality grass and legume forage samples.