Forages and Pastures: Emerging Techniques for Predicting Forage Quality

384 Impact of cell wall lignification on forage digestibility. H. Jung*[1,2], [1]*USDA-ARS*, *St. Paul, MN*, [2]*University of Minnesota*, *St. Paul*.

The existence of a negative relationship between lignin concentration and digestibility of forages has been known for over 50 years; however, understanding the causal factors has proven difficult. Lignin is a polymer composed of phenylpropanoid units. The biosynthetic pathway for lignin precursor synthesis has been drastically revised with elucidation of the major flux route. Grasses have abundant ferulate esters on arabinoxylans, unlike legumes, and these ferulates act as nucleation sites where lignin deposition and growth occurs, with the ferulates acting as cross-linking agents of lignin to cell wall polysaccharides in grasses. Lignin concentration increases during forage maturation as more cell wall material is formed. In grasses virtually every tissue type undergoes secondary wall thickening and lignification whereas legumes deposit lignin in just a few tissue types. Lignified legume tissues are virtually indigestible. In contrast, lignified grass tissues can be extensively, but not completely, digested by rumen microbes. Measuring lignin concentration is problematic because all methods are empirical. Methods either hydrolyze the cell wall polysaccharides leaving a lignin residue (acid detergent and Klason) or oxidize lignin away (permanganate and acetyl bromide). In general, lignin concentration estimates range from Klason>acetyl bromide>permanganate>acid detergent methods. It has been proven that acid detergent lignin severely under-estimates lignin content of forages, particularly grasses. Fortunately concentration estimates are correlated among methods (r~0.75) and all methods are of similar accuracy in predicting digestibility. Lignin's value for predicting digestibility is greater when forages cover a maturity range. The lignin/digestibility relationship is weak or non-existent if forages are from a single species and similar maturity. Lignin composition and, in grasses, ferulate cross-linking have been proposed to modify the lignin/digestibility relationship; however, experiments examining these factors have been mixed. Lignin limits forage digestibility through an interaction of tissue localization and structural incorporation into specific cell wall layers.

Key Words: Forage, Lignin, Digestibility

385 New applications of near-infrared reflectance spectroscopy for forage quality assessment. S. Coleman*, *USDA ARS Subtropical Agricultural Research Station*, *Brooksville, FL*.

Near-infrared reflectance spectroscopy (NIRS) has now been used in agriculture, specifically for forage quality analysis, for about 30 yrs. Due to its speed, many new applications have been developed, including medicine and pharmaceuticals. It is a secondary technique that requires proper calibration with samples that adequately represent the population for which it is to be used. In agriculture, NIRS was first used to estimate moisture and oil in seeds. In 1976, crude protein, neutral detergent fiber, acid detergent fiber, in vitro dry (or organic) matter digestibility, in vivo apparent digestibility and in vivo intake were all estimated by NIRS. Routine use of NIRS over the next 25 years involved estimating chemical composition, which in turn was used to predict intake and in vivo digestibility. Several databases have now been developed in Europe and Australia in which NIRS was used to directly predict in vivo digestibility with acceptable accuracy and precision. Intake has been a bit more problematic due to non-forage factors that influence ad libitum intake. However, research demonstrates that NIRS contains the necessary information to predict potential intake. Routine use now includes prediction of in vitro cell wall digestibility and other chemical components needed to predict both in vivo digestibility and intake. Analysis of fecal samples for direct prediction of both intake and digestibility have been successful within the limits of the calibration database. The most recent application includes in situ analysis of forage quality with handheld units. This negates the necessity of clipping, drying and grinding pasture samples. Another advantage is non-destructive monitoring the processes of maturation of the same canopy. The method was applied to a grazing trial, and supplementation was recommended from analyses obtained in situ. Calves supplemented based on remote sensed data for crude protein gained more rapidly than those supplemented based on standard, time-based management.

Key Words: Forage Analysis, NIRS, Remote Sensing

386 The need for new approaches in predicting forage quality: challenging the conventional wisdom. J. Moore*, *University of Florida*, *Gainesville*.

Forage quality is defined as animal performance, or voluntary intake of digestible nutrients, when forage is fed alone and ad libitum. Indices of forage quality are based on in vivo intake and digestibility (e.g., nutritive value index [Crampton et al., 1960], and relative feed value [RFV] developed by the Hay Marketing Task Force of the American Forage and Grassland Council [AFGC] in 1978). Both intake and digestibility are required because, across a wide array of forages, they are not related closely. Although the concepts are sound, the challenge has been to predict intake and digestibility from laboratory analyses. The conventional wisdom of the last 40 years is that acid detergent fiber (ADF) and neutral detergent fiber (NDF) are acceptable predictors of digestibility and intake, respectively. These assumptions are based on papers by Van Soest and regression equations published by the AFGC task force. The intake prediction was revised to reflect the assumption that NDF intake is a constant 1.2% of BW. Publications on forage-only diets show, however, that voluntary intake of NDF (% of BW) varies widely among forages. Furthermore, publications relating ADF and NDF to digestibility and intake show unacceptable relationships when the sample population includes an array of forage genotypes and environments. A new index, relative forage quality (RFQ), has been proposed. It is based on voluntary intake of total digestible nutrients (TDN). The main value of the RFQ system is new multivariate prediction equations for intake, and summative equations for TDN based on the new Dairy NRC equations. In both cases, NDF digestibility is an important component, and it is estimated by either lignin concentration, in vitro NDF digestion, or Near Infrared Reflectance Spectroscopy (NIRS). Over the past 30 or 40 years, many studies have suggested the potential of predicting in vivo intake and (or) digestibility directly from lignin, fermentation rates, and NIRS. Finally, these techniques are receiving the attention they deserve, as per this symposium.

Key Words: Intake, Digestibility, Laboratory

387 Application of rates of fermentation to prediction of forage intake. M. Blummel*[1] and E. Grings[2], [1]*ILRI*, *Patancheru, Andhra Pradesh, India*, [2]*USDA-ARS*, *Miles City, MT*.

In vitro techniques used in ruminant nutrition can be classified into those that estimate digestibility/degradability gravimetrically by quantifying insoluble incubation residues and into those that measure appearance of products of fermentation, such as gases. While *in vitro* gas techniques have received much attention over the last two decades due to the ease with which fermentation kinetics can be measured, there is little evidence of their superiority over gravimetric techniques in the prediction of feed intake. Furthermore, a conceptual problem with *in vitro* gas measurements arises when rejecting proportional constancy between main products of microbial degradation: short chain fatty acids (SCFA), microbial biomass, and gases. While there is a close stoichiometrical relationship between SCFA and gas production, a potential competitive relationship for substrate utilization between these two products and microbial biomass can be demonstrated. This problem can be overcome by measuring *in vitro* true substrate degradability concomitantly with gas production. Intake predictions for a wide range of temperate and tropical roughages based on *in vitro* 1) gas production rates, 2) true degradability, and 3) combinations of both, show that the latter approach can result in more accurate prediction of intake than measurement of either alone.

Key Words: Gas Production, Intake, Degradability