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Predicting Degradation Characteristics from Chemical Composition and Soluble Fraction of Poor Quality Roughage Diets

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Abstract

This study was conducted to explore the feasibility of predicting quality from selected chemical and degradability measurements for two browses (Alchornea cordifolia (A), Ficus coapensis (F), and two crop residues (maize (M) and rice stover (R.) and their mixtures; Degradation characteristics were determined in the rumen of three West African Dwarf (WAD) goats, three WAD sheep and three White Fulani steers. Each animal was fitted with a permanent ruminal canulae, and was routinely fed on Panicum maximum and equal amount officus and alchornea at a ratio of 70:30 respectively (dry matter basis). The DM disappearance values were fitted to the exponential equation $P = a + b\ (l\text{-}e^{*1})$ where P is amount degraded at time (t) as the soluble fraction, b is the potentially degraded fraction, and c is the rate at which b degrades. Effective degradability (ED) was also determined. The ED of the feeds and their mixtures varied from 256 to 373 (g/kg). The experimentally determined values were compared, to calculate values based on predictions from individual chemical components (separately or combined) with the inclusion of the soluble fractions in the regression analyses.

The use of the individual chemical components (NDF, ADF, cellulose, and lignin) was not effective in predicting the degradation characteristics. When the chemical components (cellulose, hemicellulose, lignin and total nitrogen) were combined in a multiple regression analysis, prediction was also poor. However, the results suggest that cellulose and lignin contribute significantly to the prediction. The inclusion of the washing loss in the multiple regression analysis with the combined chemical components improved the prediction of ED. Calculated ED values from predictions correlated well with the experimentally determined ED. The coefficient of correlation between the observed and calculated ED values was highest for cattle (0.95) followed by sheep (0.93) and goats (0.77).

Keywords: Prediction of degradation, browses, crop residues, and ruminants.

Introduction

Feed intake in ruminants is highly variable and is influenced by interplay of many factors involving the animal, rumen microorganisms and the forage (ARC 1980, Ellis *et al*, 1988, Flachowsky, 1989). Predictions of voluntary dry matter intake of forage from *in. vivo* digestibility estimates is not accurate (Chenost *et al.*, 1970, Orskov 1989) even though the ability to do so would be helpful to feed scientists and producers.

Feed evaluation by the use of the nylon bag technique is simple and appropriate for assessing the degradation of low quality roughage (Orskov *et al.*, 1980). Degradation characteristics of feed have been used to predict animal feed intake (Carrol *et al.*, 1991, Kibon and Orskov 1993, Reid *et al* 1988). The DM disappearnce after 24 and 48 hours, incubation and the potential degradation (a + b) are correlated to voluntary dry matter intake (Hovell *et al,* 1986). Prediction of intake from chemical composition of feed, excluding lignin, has not been successful (Reid, et al, 1988).

Although degradation characteristics obtained from nylon bag degradation studies are useful in predicting animal performance (Orskov. 1989), it is time consuming, and could be expensive in terms of experimental materials especially cannulated animals, which are difficult to maintain. An alternative approach, which is explored in this study, is combining chemical composition with measurement of the soluble fractions of feed in a multiple regression analysis to predict degradation characteristics. The objective of this study was to predict effective degradability of roughage mixtures from chemical composition and soluble fraction in an attempt to explore methodologies for predicting feed intake from simply determined feed characteristics.

Materials and methods

Feeds

Degradability characteristics of individual forages as well as feed mixtures were determined. The feed samples used were common feed resources of the derived savannah area; two browse plants *(Alchornea cordifolia (A), Ficus capensis (F)* and two crop residues (maize (M), rice stover (R) and their mixtures). The feed mixtures consisted of 10, 20 or 30% of each browse (the supplement) with the crop residue as the basal component.

Animals and management

Three male West African dwarf (WAD) goats, 3 rams WAD sheep and three male White Fulani steer with average body weight of 18,30 and 200 kg respectively fitted with rumen cannulae were used for the degradation studies. The animals were fed on equal amount *officus* and *alchornea* (30%) and resh guinea grass *(Panicum maximum)* (70%) *ad libitum* in individual pens (DM basis).

Chemical analysis

The fibre components of the feeds: NDF, ADF and cellulose were measured by the methods of Goering and Van Soest (1970). Hemicelluloses was calculated as the difference between NDF and ADF

Rumen and degradability

The DM degradability of the samples was determined using the nylon bag technique (Orskov et al. 1980). Three grams each of the samples were weighted into nylong bags (10 x 15 cm, pore size: 40-50 mm) and incubated in the rumens of goats, sheep and cattle. The samples were dried and ground through a laboratory hammer mill equipped with a 3-mm screen. Duplicated samples were incubated in each animal for each incubation period (12,24, 48, 72, 96). The DM disappearance was fitted to the exponential equation P = a + b ($l\text{-}c^{-ct}$) (Orskov and McDonald 1979) where P = degradation at time t (h), a = soluble fraction, b = insoluble but potentially degradable fraction, a + b = potential degradation and c = rate of degradation of b.

Prediction of degradability

The effective degradability P = a + be (c

Table 1. Chemical composition of the four feeds g/kg DM) used to determine degradation characteristics.

	NDF	ADF	CLL	HEMCELL	LIGNIN	TN
Maize stover	620	458	-236	162	94	12
Rice stover	672	412	298	230		10
A.cordifolia	344	310	166	134	132	22
Ficus capensis	*492*	*486*	226	*110*	*248*	22

NDF= Neutral detergent fibre, ADF = Acid detergent fibre, CLL= Cellulose, TN= Total nitrogen

Table 2. Values of experimental and predicted effective degradabilities (pED) for the feed in the animals (g/kg)

	ED Goats	ED Sheep	ED cattle	pED
Maize stover	256	272	287	276
Rice	327	372	371	386
Alchonia	361	360	365	330
Ficus	291	294	303	254
MA10	267	281	292	281
MA20	283	298	308	286
MA30	290	301	318	292
MF10	275	288	301	273
MF20	280	298	306	270
MF30	288	301	301	267
RA10	320	358	364	373
RA20	324	359	364	373
RA30	314	357	367	366
RF10	320	350	373	371
RF20	318	357	358	355
F30	316	360	360	341

Correlation coefficient	pED -ED goats	0.766
	pED -ED sheep	0.929
	pED - ED cattle	0.950

k) was estimated according to McDonald (1981). Three methods were used for the prediction of ED and degradation characteristics.

(1) Predictions based on individual chemical components of feeds: This involved the use of a simple linear regression model, to analyze the effect of *oa.ch* feed component separately, including cellulose and lignin on (ED) and degradation characteristics (a,b,c).

(2) Predictions based on the combined chemical components of feeds: This involved the use of a multiple linear regression model to analyze the effect of the combined chemical components (cellulose, hemicellulose, lignin and total nitrogen) on ED and degradation characteristics (a,b,c)

(3) Predictions based on the soluble fraction or washing loss and the chemical components (cellulose, hemicellulose and lignin) of the feed: This analysis was based on the following equation

PED =a+ (bc(k) exp-(c + k)t} Where PED = Predicted effective degradability

Cellulose and hemi cellulose content multiplied by 0.8, a coefficient which estimates the non- degradable fraction of these fibers.

c = constant rate of disappearance of b, obtained from the simple linear regression equation c = 0.0350 - 0.001 (lignin (%) where 0.035 is the coefficient of regression. The estimation of c from lignin % was based on the hypothesis that c is the same for cellulose and hemicellulose and is constant when the plant material contains no lignin. Thus lignin is the only factor that affects the rate of disappearance (c.)

k = rate of removal of feed particles from the rumen and was used to calculate the experimental effective degradability (0.04/h)

T = time (hours)

Statistical analysts

Correlation analysis was used to analyze the difference between the predicted effective degradability and those obtained experimentally for the goats, sheep and cattle.

Results and Discussion

Chemical composition of the four sole feeds is presented in Table 1. The use of chemical components was not effective in predicting the degradation characteristics of these feeds (Table 2.).

The regression coefficients were far above one for cellulose and strongly negative for hemicellulose, indicating that these were not accurate. However, the P value of the models was always less than 0.05 which was taken as indication that at least one variable was important in explaining the model. Only cellulose and lignin had coefficients, which differed significantly from zero in almost all the models (0.99 to 2.38 with a mean of 1.7 for cellulose and -1, 15 to -2.73 with a mean of-1.7 for lignin).

It was concluded therefore that effective degradability constants could not be predicted from the multiple regression analysis combining feed components. Other studies have shown that the nutritive value of feeds could be predicted with good accuracy from its chemical components. Donker and Naik (1979) obtained good results for total digestible nutrients (TDN) and estimated net energy of dairy cow rations from multiple regression equation combining crude fibre and crude protein. Likewise, Dewhurst *etal.,* (1986) achieved good agreement between observed and predicted metabolizable energy concentration in forages for ruminants from multiple regression analysis incorporating the concentrations of ash, CP, EE, sugars, alpha glucan, betaglucan, lignin, volatile fatty acids and lactic acid. The ineffectiveness of the combined chemical components to predict ED could be related to the fact that the soluble fraction or washing loss of the feed was included in the equation (McDonald 1981)

Exclusion of the soluble fraction could lead to a gross underestimation of the value of effective degradability especially in feeds with high washing loss. Table 2 shows the experimental and the predicted effective degradability values of the feed samples for goats, sheep and cattle. The predicted ED is based on the combination of the soluble fraction and the chemical components in a multiple regression analysis. The coefficient of correlation between the experimental and predicted effective degradability for each species are also presented. The comparison of predicted ED and ED obtained experimentally showed better correlation in cattle (0.95) and sheep (0.93) and in goat (0.77). The lower value obtained for goats might also be due to the significant ($p<0.05$) difference among the individual goats used for the study.

The use of the estimate a, b c from chemical composition (hemicellulose, cellulose and lignin) and the soluble fraction resulted in reasonable prediction of ED. It has been shown that the voluntary dry matter intake of hays by sheep could be predicted using a multiple regression equation when the soluble fraction and the rate of degradation are included in the model (Crrol et al 1991). Animal intake performance has also been predicted from potential degradability a+b values Kibon &Orscov 1993, Orscov *et al* 1988). However, in both studies (a+b) accounted for 0.65, 0.57,0.15 and 0.41 of the variability in apparent DM digestibility, DM intake, apparent digestible DM intake and growth rate, respectively. The use of a,b,c in the multiple regression improved the accuracy and values obtained were 0.88 for apparent DM digestibility, 0.99 for DM intake, 0.92 for apparent digestible DM intake and 0.99 for growth rate (Kibon and Orscov, 1993).

This study to predict ED from chemical characteristics was done to ascertain the feasibility of avoiding animal experimentation thereby saving time and expenses. It was concluded that it is possible to improve the model by including an estimate of the soluble fraction. However it remains to be seen if this method could be accurately applied to other feed resources.

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