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Effect of herbage composition on the digestibility and voluntary feed intake of kikuyu

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Abstract

Digestion trials using sheep and voluntary feed intake (VFI) trials using long yearling heifers in Calan gates were conducted in the spring, summer and autumn over 5 years. These data and the chemical composition of the herbage were regressed on DMD and VFI. Excluding the mineral fractions, only three of the chemical components of the herbage emerged as important, namely, the DM content of the herbage as fed, accounting for 32% of the variance in DMD, the NPN content of the herbage accounting for only 12.2% of the variance and the ash content of the herbage accounting for 15.9% of the variance in digestibility. Of the macro-mineral components, Ca, Mg and P tended to be positively associated with DMD, while Na and K were significantly related to DMD. NDF was positively correlated to VFI, accounting for 37% of the variability in intake, while non-protein nitrogen was negatively correlated to VFI, although it did not account for much of the variability (11%) in VFI. Ca was also positively correlated to VFI, also accounting for very little of the variation in VFI (11.7%). Herbage Mg had a positive influence on VFI, accounting for 24% of the variation in VFI. Both DMD and VFI were highly negatively influenced by the moisture content of the herbage.

Keywords: *Pennisetum clandestinum*, DMD, VFI, chemical composition
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Introduction

The chemical composition of herbage has been used to predict digestibility (Minson, 1982). The ability to accurately predict the nutritive value of kikuyu herbage with a relatively easy and cheap chemical analysis would be of immense value to dairy farmers utilising kikuyu as a roughage source in the summer months in the KZN Midlands. This study investigated the relationship between the chemical fractions and nutritive value of kikuyu.

Materials and Methods

Kikuyu pasture was fertilized at two levels of nitrogen (N), namely 50 and 200 kg N/ha, after mowing and clearing the plots, to induce low and high levels of N in the herbage. The subsequent growth was harvested at 20, 30 and 40 days of re-growth. Digestion trials using sheep, determined using the *in vivo* technique described by Juko *et al*. (1961) and voluntary feed intake (VFI) trials using long yearling heifers, determined using Calan feed gates (Broadbent *et al*., 1970), were conducted in the spring, summer and autumn for 5 consecutive years for dry matter digestibility (DMD) and 3 for VFI.

Five years of digestibility trials, amounting to 82 trials and three years of intake trials, amounting to 38 VFI trials were pooled. The chemical composition of the herbage, comprising ADF, NDF (Van Soest & Robertson, 1980), NPN (Marais & Evenwell, 1983), CP, ash (AOAC,1980) and minerals was regressed on DMD and VFI, using the multiple linear regression techniques, including the stepwise regression analysis procedure, of GenStat v9.1 (GenStat, 2006), to examine the influence of herbage composition on the nutritive value of the herbage.

Results

Excluding the mineral fractions only three factors emerged as important in predicting DMD, namely, the DM content of the herbage, as fed, accounting for 32% of the variance in DMD, the NPN content of the herbage accounting for only 12.2% of the variance and the ash content of the herbage accounting for 15.9% of the variance in digestibility. However, a combination of the two factors, DM and NPN improved the correlation with DMD, accounting for 52% of the variation in DMD. Including ash in the regression improved the variance accounted for in DMD to 60.7%. These equations are expressed in Table 1.

Of the macro-mineral components, Ca (P = 0.11), Mg (P = 0.064) and P (P = 0.147) tended to be positively associated with DMD, while Na and K were significantly related to DMD. A combination of minerals proved

Table 1 Regression equations quantifying the relationship between chemical component (g/kg DM) and DMD

Y	=	A	b_1	X_1	b_2	X_2	b_3	X_3	n	R^2	P
DMD	=	397	+ 1.31	$DM_{as\ fed}$					94	0.323	<0.001
DMD	=	720	- 6.97	NPN					58	0.122	<0.004
DMD	=	404	+ 1.55	$DM_{as\ fed}$	- 5.59	NPN			58	0.526	<0.001
DMD	=	266	+ 1.48	$DM_{as\ fed}$	+ 1.48	ash	- 4.83	NPN	58	0.607	<0.001
DMD	=	591	+ 116	Na					48	0.160	0.002
DMD	=	532	+ 4.54	K					48	0.069	0.038
DMD	=	255	+ 51.1	Mg	+ 5.79	K	+ 87.8	Na	48	0.296	0.003

significant in accounting for 29.6% of the variation in DMD (Table 1).

The VFI's of the heifers, over all the seasons, are expressed in Table 2. Crude protein, albeit with a negative trend (P = 0.18), and ADF, with a positive trend (P = 0.129), were not significantly correlated to VFI. Neutral detergent fibre was positively correlated to VFI, accounting for 37% of the variability in intake. Non-protein nitrogen was negatively correlated to VFI, although it did not account for much of the variability (11%) in VFI. Ca was also positively correlated to VFI, also accounting for very little of the variation in VFI (11.7%). Herbage Mg had a positive influence on VFI, accounting for 24% of the variation in VFI. The DM content of the herbage accounted for 71% of the variation in intake.

Table 2 Regression equations quantifying the relationship between chemical component (g/kg DM) and VFI (kg/100 kg BW)

Y	=	A	b_1	X_1	b_2	X_2	b_3	X_3	n	R^2	P
VFI	=	- 1.03	+ 0.005	DMD					38	0.610	<0.001
VFI	=	- 0.60	+ 0.015	$DM_{as\ fed}$					38	0.680	<0.001
VFI	=	3.88	- 0.032	$DM_{as\ fed}$	+ 0.000126	$DM_{as\ fed}^2$			38	0.709	<0.001
VFI	=	- 1.94	+ 0.022	Ash	- 0.008	CP	+ 0.005	NDF	29	0.564	<0.001
VFI	=	- 3.21	+ 0.007	NDF					38	0.370	<0.001
VFI	=	2.82	- 0.043	NPN					30	0.110	0.038
VFI	=	- 0.41	+ 0.728	Mg					24	0.240	0.008
VFI	=	0.46	+ 0.064	Ca					24	0.117	0.056

The DM concentration of the herbage in the trials varied ranged from 134 g/kg to 283 g/kg with a mean of 188.7 g/kg. The data was re-analyzed with all trials containing a DM lower than the mean value excluded from the analysis, to determine if the negative effect of DM (moisture) on DMD was limited to the wetter herbage. Both DMD (P = 0.039) and VFI (P = 0.02) were still negatively influenced by the moisture concentration of the herbage, albeit not as strongly, with higher moisture (lower DM) concentrations still depressing DMD and VFI.

Discussion

Moisture concentrations exceeding 780 g/kg fresh material are generally considered as having a detrimental effect on voluntary intake (Minson, 1990). However, there are exceptions to the generalized rule. Holmes & Lang (1963) concluded that neither internal water content nor external rain water restricted DMI in forages. Johnson *et al.* (1968) found that dry matter intakes were not related to stage of maturity, season of harvest, DM content, crude fibre content or digestibility for guinea grass (*Panicum maximum*).

The effect of water on digestibility is not conclusive, with most references concluding that moisture has no effect on digestibility (Garwood *et al.*, 1979; Danelon *et al.*, 2002). However, Reid *et al.* (1959) in a study of 28 forages representing a variety of temperate species, found that increasing DM content of the herbage negatively impacted on herbage digestibility. In contrast, Yoelao *et al.* (1970) observed an increase in digestibility in lucerne or berseem due to wilting. Danelon *et al.* (2002) found no response to wilting in fermentation

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characteristics and digestibility of lucerne. However, Grant *et al.* (1974) found that wilting Napier grass markedly increased the intake and digestibility of the dryer forage as opposed to higher moisture forage. Similarly, Pasha *et al.* (1994) found that the digestibilities of DM, NDF and ADF were greater for dried herbage relative to high moisture frozen forage. Similarly to this data, no significant interactions between forage maturity and moisture content were observed by Pasha *et al.* (1994). Pasha *et al.* (1994) indicated that greater ruminal NH_3N may be a possible inhibitor of intake on high moisture forages.

Chemical composition is the generally accepted measure of nutritive value for herbage. Pattinson (1981) found that the low intake of kikuyu was unrelated to CP, ADF and *in vitro* dry matter digestibility. Austin (1980) found that the only plant component associated with acceptability in kikuyu was the N fraction, which was negatively associated with acceptability. Austin (1980) also found that nitrate levels in kikuyu were negatively correlated (-0.356) to acceptability, as were herbage N levels, albeit weaker (-0.284) indicating that nitrate was the causative agent; nitrate and N being highly correlated. Pienaar *et al.* (1993) found that the N content of the leaves of kikuyu was negatively related to VFI's. Similarly, Pienaar *et al.* (1993) found that rumen ammonia levels were negatively associated with feed intake, all other factors showing no relationship with VFI.

Austin (1980) found that ADF was variably associated with acceptability, significantly positive in one trial, with a slight positive correlation but non-significant correlation overall. Karnezos (1986) found that crude fibre levels in kikuyu herbage were positively correlated with average daily gain (ADG) in steers grazing kikuyu and considered that this positive relationship was possibly associated with herbage availability. Dugmore *et al*. (1986) recorded a negative correlation between crude protein and digestible organic matter, while a lower individual animal performance was recorded with increased levels of N fertilization by Tainton *et al*. (1982) and Karnezos (1986). None of the chemical components proved to be accurate in predicting the digestibility of kikuyu (Dugmore & Du Toit, 1988) or intake for a range of pastures (Meissner *et al*., 1988). Pattinson (1981) concluded that kikuyu seems to be a special case in that the low intakes seem to be contrary to all the conventional quality attributes determined. Karnezos (1986) modelled the ADG rates of steers grazing kikuyu, using herbage availability and chemical composition. The only chemical components which contributed significantly to the model were Ca and N, with N negatively correlated to ADG in steers.

Austin (1980) investigating the effect of N, phosphate, calcium and magnesium (dolomitic lime) fertilization on minerals in kikuyu found that the acceptability of the pasture was not affected by any of the minerals recorded (Ca, P, K and Mg). This is in contrast to Karnezos (1986) who found that Ca was the only plant fraction that significantly influenced live weight gain in steers.

The positive effect of Na on digestibility is not unexpected, considering kikuyu is a natrophobe, with particularly low Na levels in the leaves. Reason *et al.* (1989) found that cows grazing kikuyu were Na deficient, while Davison *et al.* (1980) found that supplementing NaCl increased milk production on tropical pasture.

This data confirms the observation by Butterworth *et al.* (1970) that interactions among the various plant constituents were so high as to obscure meaningful relationships and that the accuracy of prediction of digestibility from proximate analysis in tropical species was in most cases extremely low.

Conclusion

The chemical composition of kikuyu cannot be used to accurately predict the nutritive value of kikuyu herbage and at best should only be used to determine if the minimum requirements for protein, fibre and minerals are met in the diet. The major negative effect of herbage moisture of kikuyu on its digestibility and intake has great implications on grazing management strategies for kikuyu.

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