Short Communication

The potential of the weed, *Commelina diffusa* L., as a fodder crop for ruminants

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Abstract

The objective of this study was to evaluate the potential of *Commelina diffusa* L. as a ruminant feed. *Commelina diffusa* belongs to the *Commelinaceae* family, a family of plants that is generally poorly investigated with respect to ruminant nutrition. The species was evaluated in terms of its chemical composition, and through the *in sacco* technique, its rumen degradation characteristics. Rumen degradability was determined in three mature female goats, each fitted with a permanent rumen cannula. *Commelina diffusa* contained 177 g crude protein (CP)/kg dry matter (DM) and its CP had a rumen degradability of 74.1 ± 2.7%. Most of the DM and organic matter (OM) were lost during the first 36 h of incubation and the cell wall components after 48 h of incubation. Maximum (120 h) DM, OM, neutral and acid detergent fibre, hemicellulose and cellulose disappearances from the bags incubated in the rumen were 66.3, 57.8, 55.6, 55.2, 56.7 and 44.3%, respectively. Rumen degradation of DM and OM was correlated (r^2 = 0.66), but significantly different. It is concluded that, from a nutritional point of view, *C. diffusa* compares well with many commonly used fodder crops and could be used as protein source for ruminants on smallholder farms.

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Ruminant production systems throughout the world are based on forages (FAO, 1996), hence the need for continued research on both wild and cultivated plants. Though largely considered as a weed, the *Commelinaceae* family is one of the largest and most widespread natural tropical and sub-tropical plant families on earth (Hardy *et al*., 2001) with a wide range of uses. *Commelina forskalaei* in particular has been regarded as good ruminant fodder and suitable for ensiling (Geesing & Djibo, 2001). According to earlier research, *Commelina diffusa* L. contributed to the diet of village dairy cows in rural areas of Mauritius (Boodoo *et al*., 1990). *Commelina benghalensis* has also been reported to constitute a major proportion of herbage fed to dairy goats in Tanzania (Ingratubun *et al*., 2000), while *Commelina communis* L. forms an important component of the diet of grazing ruminants in Florida rangelands (Mullahey *et al*., 2002). Gachathi (1989) and Osolo *et al*. (1994) reported that *C. benghalensis* and *Commelina africana* L. are used as cattle feed on smallholder resource-poor farms in Kenya. *Commelina erecta* (dayflower) is said to be a preferred feed resource for white-tailed deer (Jones, 1982) and is grazed readily by cattle (Everitt *et al*., 1999). Under wet conditions most of these species regenerate fast, ensuring a sustainable source of nutrients for ruminant livestock. Many smallholder farmers in Kenya open-graze their ruminant livestock on freshly harvested crop fields where they scavenge on both crop residues and weeds. At the onset of the dry season animals prefer feeding on mixtures of weeds (*Commelinaceae*, *Amaranthaceae* and others) growing naturally in the farm environment, rather than tough, low quality crop residues. Laboratory analyses of grab samples of a mixture of these weeds revealed crude protein (CP) concentrations twice that of low quality roughages (Lamers *et al*., 1996). This implies that such weeds growing naturally at farm level can and are indeed being used by farmers to supplement conventional feed resources both during the wet and dry season. The current study was undertaken to determine the chemical composition and through the *in sacco* (nylon bag) technique, the CP, dry matter (DM), organic matter (OM) and cell wall degradation characteristics of *C. diffusa*. The objective was to evaluate its potential as a ruminant feed, particularly, for smallholder farms in the tropics where availability of land for fodder production has become a major constraint.

The test feed, *C. diffusa* (18-week old), grows naturally underneath citrus plants on the Yangzhou University farm. The material was harvested fresh at 5 cm above ground level from four different sites of 9 m^2 each and about 5 m apart. All the harvested materials per site, free from contaminants, were chopped, into small pieces of about 2 cm using a cutlass, and then mixed thoroughly. From each site three separate composite samples of 5 kg fresh material each were taken for DM determination and chemical and rumen degradability studies. To account for sampling and analytical variability, the fresh samples were further divided into two portions of about 2.5 kg each per site and treated as independent samples (N_{total} = 8). Dry matter was determined by drying the two sets of fresh samples per site in an oven at 135 °C for 2 h (Abdulrazak & Fujihara, 1999). For chemical analyses, samples were dried at 65 °C for 24 h and then ground to pass through a 2.5 mm sieve (Abdulrazak & Fujihara, 1999). Crude protein (g N/kg DM x 6.25) was determined, using the Kjeldahl method (AOAC, 1990). The cell wall components were determined according to the methods described by Van Soest & Robertson (1985) and Abdulrazak & Fujihara (1999). Hemicellulose and cellulose were also determined as described by Abdulrazak & Fujihara (1999). Ash was determined by igniting feed samples (1 g each) for 3 h in a muffle furnace preheated to 550 °C (Abdulrazak & Fujihara, 1999).

Rumen degradation characteristics were measured using the *in sacco* technique (Ørskov *et al.*, 1980) with nylon bags of pore size 40 µm (inner diameter: 6.5 x 12 cm). Three mature non-lactating female goats weighing an average of 28 kg and fitted with permanent rumen cannulae were used. They were housed together at Yangzhou University farm in a well-ventilated draft-free pen with a slatted wooden floor. The goats were fed a basal diet comprising of about 75:25 maize silage (360 g DM/kg; 80 g CP/kg DM) to dry cured lucerne (920 g DM/kg; 190 g CP/kg DM) *ad libitum*. The diet was fed as two equal meals at 08:00 and 16:00 every day from 14 days before commencement of the study and throughout the trial. The goats had free access to clean drinking water and a mineral supplement. There were three repeats with a total of 36 bags each (N_{36X3}=108) and 12 bags (including the 0 h) per goat per run (giving a total of three bags for each incubation duration per run). Due to unprecedented death of one goat, the fourth repeat was ignored. In each repeat, representative samples of 5 g each were weighed into the bags, which were labelled and weighed. Eleven bags were inserted simultaneously into the rumen of each goat and withdrawn sequentially. Duration of incubations were 4, 6, 8, 12, 14, 24, 36 48, 72, 96 and 120 h. After each incubation period, the respective bags were removed, dipped immediately into cold water and then washed in a domestic washing machine with cold water for 30 min, and then dried at 65 °C for 48 hours. To determine the washing losses, three bags for each run, containing 5 g each of the test feed, were soaked in a waterbath kept at 39 °C for 1 h and then washed and dried as the incubated bags. After the 48 h drying period, all the bags were cooled in a desiccator for 30 min and then weighed. About 0.5 g of the residue was taken from each bag and oven-dried at 135 °C for 2 h to determine total residual DM (Abdulrazak & Fujihara, 1999). Portions of the residue per incubation were further subjected to chemical analyses, as described above. The nutrient composition of *C. diffusa* is presented in Table 1.

Table 1 Mean nutrient composition of *Commelina diffusa* L.

Component	N	Mean	% CV
Air dry matter (g aDM/kg Fresh matter)	8	193	12.52
Total dry matter (g tDM /kg aDM)	8	893.8	3.89
Crude protein (g CP/kg DM)	8	177.1	8.49
Neutral detergent fibre (g NDF/kg DM)	8	360.8	19.05
Acid detergent fibre (g ADF/kg DM)	8	227.2	21.74
Acid detergent lignin (g ADL/kg DM)	8	314	18.72
Hemicellulose (g /kg DM)	8	139.6	13.83
Cellulose (g /kg DM)	8	179.8	20.51
Ash (g /kg DM)	8	205	26.53

CV – Coefficient of variation

Data for the degradation of the *in sacco* DM, OM, CP and cell walls were fitted to the first order kinetics defined by the exponential equation of the form: $p = a + b\ (1 - e^{-ct})$; (Ørskov & McDonald, 1979): where p represents degradation of DM, OM, CP and cell wall components at time t; (a + b) is their potential degradation and c is the rate of their degradation. Effective rumen degradation (ED) of components was calculated as: $ED = a + (b \times c) / (c + k)$, assuming a rumen outflow rate (k) of 5%/h. Degradation constants, a, b and c, were derived using the statistical packages, SAS (2002) and GraphPad (2005). The disappearance of feed components was graphed using curve fit nonlinear regression (user defined equation: $P = b \times (1 - e^{-ct})$ model of GraphPad (2005)).

The results revealed that *C. diffusa* has a high protein content (Table 1) compared to many tropical grasses and crop residues. Its degradation (Figure 1 & Table 2) was also high (74.1 ± 2.7%).

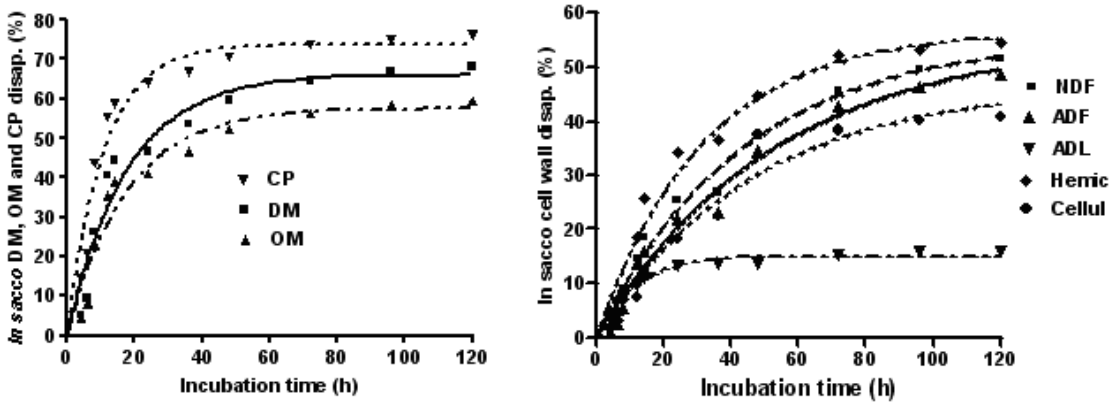

Figure 1 *In sacco* dry matter (DM), organic matter (OM), crude protein (CP) and cell wall disappearances ($p = a + b\ (1 - e^{-ct})$; Ørskov & McDonald, 1979) for *Commelina diffusa* L. over different periods of incubation

Table 2 *In sacco* DM, OM, CP and cell wall degradation parameters for *Commelina diffusa* L. (N = 9)

Component	a	b	a + b	c	ED	R^2	s.e.
Dry matter (DM)	20.1	46.2	66.3 ± 3.4	0.057	44.7	0.9324	3.40
Organic matter (OM)	17.5	40.3	57.8 ± 2.9	0.057	39.0	0.9325	2.96
Crude protein (CP)	35.8	38.3	74.1 ± 2.7	0.091	60.5	0.9342	0.31
Neutral detergent fibre	7.9	47.5	55.4 ± 2.8	0.023	22.9	0.9844	4.76
Acid detergent fibre	5.4	49.8	55.2 ± 4.2	0.019	19.1	0.978	2.96
Acid detergent lignin	7.7	7.5	15.2 ± 0.3	0.087	12.5	0.9754	1.04
Hemicellulose	8.7	48	56.7 ± 3.3	0.032	27.4	0.9637	1.76
Cellulose	5.1	39.2	44.3 ± 4.0	0.021	16.7	0.9636	2.16

a - Immediately soluble fraction; b - Insoluble but rumen degradable fraction; c - Rate of degradability (a + b); ED - Effective degradability of the components expressed by: a+b*[c/(c+0.05)]; s.e. - Model standard error

Total DM, OM and CP degradability were determined and graphically compared (Figure 1). Most of the DM and OM was lost during the first 36 h of incubation. The study revealed that the maximum (120 h) DM, OM and CP disappearance were 66.4 ± 3.4, 57.8 ± 2.9 and 74.1 ± 2.7%, respectively (Table 2). Rumen degradation of DM and OM were correlated ($r^2 = 0.66$) and significantly different ($P < 0.05$). Standard errors of the mean at 24, 48, 72 and 96 h of incubation, respectively, were 2.09, 0.99, 0.43 and 0.25 for DM and 1.83, 0.87, 0.37 and 0.22 for OM. However, the two slopes and intercepts were not statistically different (P = 0.67 and 0.37, respectively). Ruminal fermentation of the incubated feed resulted in a proportionate increase in cell wall components in the residue with an increase in incubation time. Their degradation

characteristics were fitted to exponential curves (Figure 1). Comparison of the relationship between DM and CP degradation in the rumen with time indicated high correlations (r^2 = 0.81 and 0.82, respectively; P < .0001). The Neuman-Keuls multiple comparison test of GrapPad (2005) was applied to compare pair-wise the rumen degradation of cell wall components. Large differences were observed (hemicellulose *vs.* NDF: P < 0.001; hemicellulose *vs*. ADF: P < 0.001 and ADF *vs*. NDF: P < 0.001). Incubation time influenced the cell walls disappearance (r^2 ranging between 0.56 to 0.58; P < 0.05). Disappearance of most of the NDF, ADF and cellulose occurred (Figure 1) within the first 48 h. Results indicated that ADL loss in the rumen was negligible.

Species of the plant family, *Commelinaceae*, have not been investigated extensively for their potential as fodder crops in ruminant nutrition, particularly not in the tropics where different species grow abundantly. The current study has attempted to shed light on the nutritional aspect of *C. diffusa*. From its chemical composition (Table 1) and degradation profiles (Figures 1 and Table 2), *C. diffusa* compares well with many fodder crops. The air-dry matter (aDM) and CP levels of *C. diffusa* (Table 1) are comparable to those of commonly used fodder crops such as sudan grass (*Sorghum sudanense*) (aDM: 180 g/kg DM and 170 g CP/kg DM; Stanton, 2003) and napier grass (*Pennisetum purpureum*) (aDM: 160 g/kg DM and 107 g CP/kg DM; Mbuthia & Gachuiri, 2003). Dry matter, OM, CP and cell wall degradation profiles were found to be reasonably high (Table 2). As the ruminal fermentation process is partially regulated by the fibrous content of the diet, the relatively low concentration of fibre components in *C. diffusa* (Table 1) can facilitate the colonization of the feed by the rumen microbial population, which in turn might induce higher fermentation rates, therefore improving digestibility (Van Soest, 1994). Effective degradation for protein was observed to be high (60%; Juárez-Reyes *et al*., 2004; Table 2) implying a rapid supply of N for enhanced microbial activity. The ED for the cell wall components was estimated without correction for particle loss of the washed fractions. The assumption was that this would not have a significant effect on absolute fibre degradation values as generated by the applied model. The proportionate increase in cell wall components in the residues with incubation time suggested that the soluble and readily digestible fractions were lost first, followed by the less degradable fractions.

The high level of CP and the high rumen degradability of both the CP and fibre fractions suggest that *C. diffusa* could be incorporated in ruminant diets as a protein source. This is particularly important when considering the existing protein gap at smallholder resource-poor farm level in countries such as Kenya. It is therefore reasonable to conclude that *C. diffusa* could be used as protein source for ruminants on smallholder farms.

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