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Original Article

Determination of Rumen Characteristics of Dry Matter, Crude Protein and Neutral Detergent Fiber in the Different Fractions of L*eucaena Leucocephala*

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ABSTRACT

An experiment was conducted to determine the degradation characteristics of dry matter (DM), crude protein and neutral detergent fiber (NDF) in *Leucaena* edible parts. The rate of degradation (fraction c) of DM and NDF was not significantly different (P>0.05) among the edible parts and the extent of degradation (fraction a + b) and effective degradation (ED) of DM and NDF was significantly (P<0.01) higher in leaves than in pods and twigs. Fraction (c) of CP was significantly (P<0.05) higher in the air dried leaves and twigs. The extent of degradation (fraction a + b) of CP it was significantly (P<0.01) higher in the mature pods.

Keywords: Degradation, Dry Matter, Crude Protein, Neutral Detergent Fiber, Leucaena.

INTRODUCTION

It is always necessary to identify the most likely constraints to animal production which may arise as a result of incorporating tree legumes in a farm feed management system (Blair 1989). These constraints may be due to insufficient nitrogen in the diet to support efficient rumen function, low outflow rate of digesta from the rumen which may cause distension and low feed intake, imbalance in protein-to-energy ratio and mineral deficiencies. In order to minimize or eliminate these limitations, a wide range of field and laboratory evaluation has to be done. Among the most important field and laboratory evaluations for protein supplements is feed degradability, which is a coefficient that shows the extent and characteristics of rumen fermentable nitrogen and dry matter which are available in a supplement. According to Vanzant *et al.,* (1998) feed degradability is required for the prediction of nutrient availability, feed intake and animal performance. Various *in-vitro* and *in-vivo* methods have been developed for measuring the degradability of feeds such as those reported by Ferguson *et al.,* (1967); Peter *et al.,* (1973); Wohlt *et al.,* (1973); Broderick (1978); Qrskov and McDonald (1979) and Mahadevan *et al.,* (1979) among others. The nylon bag technique that was developed by Qrskov *et al.,* (1980) allows simultaneous study of the feed degradation and movement in the rumen at different periods of time. Therefore the purpose of this study was to determine the degradation characteristics of dry matter, crude protein and neutral detergent fiber in *Leucaena* edible parts.

MATERIALS AND METHODS

Sample Preparation

Leucaena samples were collected, air-dried and ground a 2-mm sieve, and passed through a 45- µm sieve to remove all fine particles.

Degradability Study

Degradability study of *Leucaena Leucocephala* edible parts was carried out in a cannulated steer according to the nylon bag technique described by Ørskov *et al.*, (1980). Steer was fed at maintained level on a balanced roughage concentrate diet with free access to water and mineral blocks. Nylon bag (80 × 140 mm; pore, size 45µm) weighing 1-2.5 g each were used for incubation of experimental sample. The empty bags were washed; oven dry at 105°C for overnight then individually weighed and their weights were recorded. Three gram of *Leucaena Leucocephala* edible parts (shooter, leaves, pods plus seed and twigs) were put in the bag, tied with nylon ribbon and introduced into a plastic tube of 25m length above the fistula level to ease the movement of the bags inside the rumen. The bags were incubated for different periods of time 4, 8, 16, 24, 48, 72 and 96hrs. At the end of each periods of time the bags were immediately removed and put it in a cold water to stop the rumen microorganism activity then washed under tap water. The dry matter disappearance at zero time (soluble fraction) was estimated as washing loss of sample weighed into the nylon bag and rinsed though running tap water. The residues in the bags were oven dried at 105°C for overnight, cooled in desiccators and weighed. Dry residues in the bags were calculated, the percentage of dry matter loss was calculated as follow:

$$\frac{\text{Wt. of sample incubated - Wt. of residues} \times 100}{\text{Wt of sample incubated}}$$

Residual samples after incubation were mixed, pooled and made ready for analysis, the degradation kinetics of the incubated experimental diet may described by curve linear regression of NDF or CP loss from the bag with time.

$$P = a + b\,[1\text{-}\ e^{ct}]. \qquad (1)$$

Where P = Potential degradability

a = Axis intercept at time zero represent soluble and completely degraded substrate that is rapidly washed out of the bag.

b= the different between the intercept (a) and asymptote, represent insoluble but potentiality degradable substrate which is degraded by microorganism according first order kinetic.

t= Incubation time.

c= Constant rate.

A, b and c are constants fitted by an enter active Least squires procedure.

Equation (1) provides curve constants that can be used in conjunction with predicted another rates for specified diet to estimate the effective degradability of the sample.

Effective degradability = $a + \left[\dfrac{bc}{c+k}\right]$

Where a, b and c are constants as defined in equation (1)

k= Rumen sample particles out flow rate.

Then a graph was plotted by the fitted values of NDF disappearance % against time of incubation in hrs to form a curve.

Chemical Analysis

Samples of feed examined and residues were analyzed for their proximate components, DM and CP according to methods AOAC (1990). NDF, were determining according to Van Soest and Wine (1967). All the analysis was run in triplicate.

Statistical Analysis

Data were analyzed by analysis of variance for a completely randomized design (Steel and Torrie 1980).

The result from *in-situ* study fitted to model $P = a + b\ [1- e^{\ ct}]$ of Qrskov and McDonald (1979) to determine the degradation characteristics of the incubated samples.

RESULTS

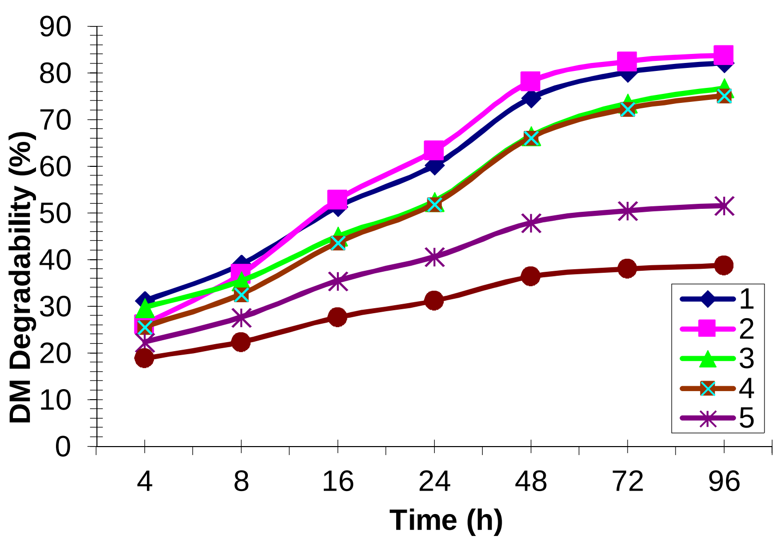
Degradation Characteristics of Dry Matter in the Rumen

The rate of degradation (fraction c) were no significantly different ($P > 0.05$) among *Leucaena leucocephala* forage edible parts and the extent of degradation (fraction a + b) of dry matter in *Leucaena* forage were significantly ($P < 0.01$) higher in the whole shoot and air dried *Leucaena leucocephala* leaves (Table1) Figure (1). The effective degradation (ED) was significantly ($P < 0.01$) higher in the whole shoot and air dried L.L leaves than the other treated leaves, pods and twigs respectively.

Table 1: DM fraction degradability (%) of *Leucaena Leucocephalal* edible parts

Parts	a	b	c	PD	ED		
					2%	5%	8%
L.L. shooter	22.03^{b}	61.5^{d}	0.04^{ab}	83.55^{d}	63.27^{e}	49.23^{e}	43.1^{e}
Air dried *L.L.* leaves	12.97^{a}	71.37^{e}	0.05^{b}	84.33^{d}	64.7^{f}	50.06^{e}	42.13^{e}
Sun dried *L.L.* leaves	23.30^{bc}	56.67^{c}	0.03^{a}	79.93^{c}	57.4^{d}	44.73^{d}	38.98^{d}
Soaked plus sundried *L.L.* leaves	17.6^{abc}	60.33^{cd}	0.035^{ab}	77.93^{c}	56.1^{c}	43.73^{c}	36.87^{c}
L.L. seed plus pods	15.6^{ab}	37.03^{b}	0.05^{ab}	52.53^{b}	41.67^{b}	34.2^{b}	30.57^{b}
L.L. twigs	14.7^{ab}	24.10^{a}	0.048^{ab}	38.8^{a}	31.77^{a}	26.67^{a}	24.06^{a}
SEM	2.28	1.39	0.06	1.1	0.36	0.55	2.42

(a) Readily degradable fraction; (b) Slow degradable fraction; (c) Rate of degradable fraction; (PD) Potential degradability; (ED) Effective degradability; (SEM) Standard Error of The Mean; a-f means with different superscript in the same row were significantly different ($P < 0.05$)



1 =shooter 2 = air dried leaves 3= sun dried leaves 4= soaked plus sun dried leaves 5= seed plus pods 6= twigs

Figure 1: The degradation characteristics of *Leucaena Leucocephala* forage dry matter in the rumen

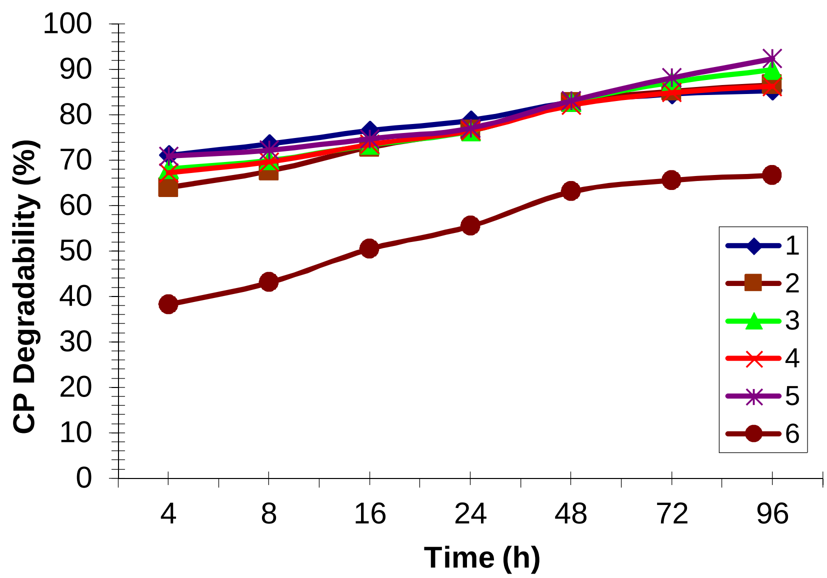
Degradation characteristics of crude protein in the rumen

The rate of degradation (fraction c) of crude protein in *Leucaena* forage were significantly ($P < 0.05$) higher in the air dried *Leucaena leucocephala* leaves and *Leucaena leucocephala* twigs. The extent of degradation (fraction a + b) of crude protein in *Leucaena* forage were significantly ($P < 0.01$) higher in the mature pods and sun dried *Leucaena leucocephala* leaves than in the air dried, soaked plus sun dried *Leucaena leucocephala* leaves, whole shoot and twigs respectively (Table2) Figure (2). The twigs were the lowest to degrade. The effective degradation of crude protein 2% was significantly ($P < 0.01$) higher in pods, while there was no significant difference between the whole shoot and leaves. The effective degradation of crude protein 5% was not significantly difference between the whole shoot, leaves and pods but were significantly ($P < 0.01$) different between the other edible parts and twigs.

Table 2: CP fraction degradability (%) of *Leucaena Leucocephalal* edible parts

Parts	a	b	c	PD	ED		
					2%	5%	8%
L.L. shooter	69.67^{c}	16.37^{a}	0.03^{ab}	86.07^{b}	79.97^{b}	76.33^{b}	74.57^{c}
Air dried *L.L.* leaves	60.30^{b}	28.28^{b}	0.04^{b}	88.57^{b}	78.1^{b}	72.1^{b}	69.17^{b}
Sun dried *L.L.* leaves	66.07^{bc}	29.13^{c}	0.02^{a}	95.16^{c}	79.78^{b}	73.83^{b}	71.43^{bc}
Soaked plus sundried *L.L.* leaves	64.6^{bc}	23.27^{b}	0.03^{ab}	87.88^{b}	78.5^{b}	73.33^{b}	71.01^{bc}
L.L. seed plus pods	69.6^{c}	25.73^{b}	0.02^{a}	96.00^{c}	81.8^{c}	75.4^{b}	73.5^{bc}
L.L. twigs	32.37^{a}	34.52^{d}	0.04^{b}	66.92^{a}	56.5^{a}	42.27^{a}	43.37^{a}
SEM	2.42	1.6	0.005	1.05	0.57	3.1	1.52

(a) Readily degradable fraction; (b) Slow degradable fraction; (c) Rate of degradable fraction; (PD) Potential degradability; (ED) Effective degradability; (SEM) Standard Error of The Mean; a-f means with different superscript in the same row were significantly different ($P < 0.05$)



1 =shooter 2 = air dried leaves 3= sun dried leaves 4= soaked plus sun dried leaves 5= seed plus pods 6= twigs

Figure 2: The degradation characteristics of *Leucaena Leucocephala* forage crude protein in the rumen

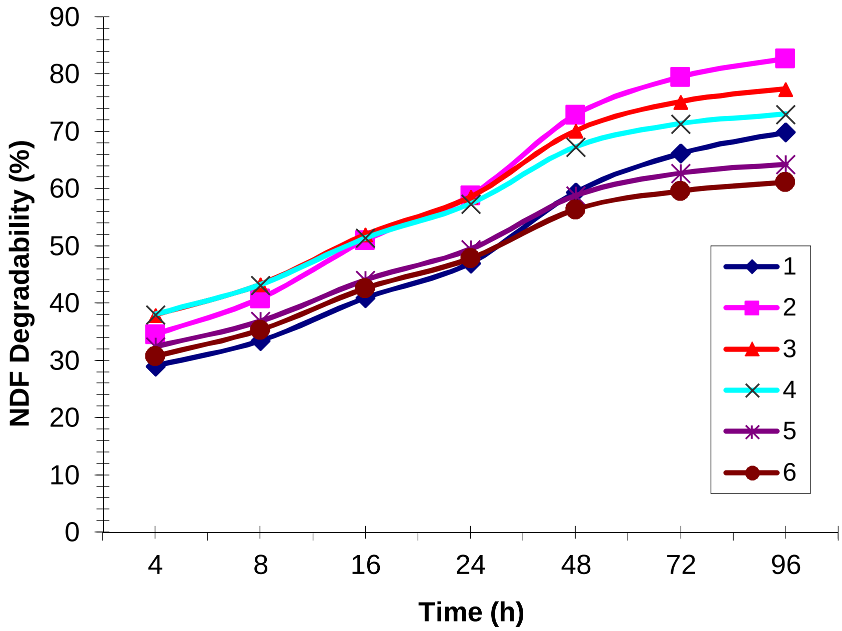
Degradation Characteristics of Neutral Detergent Fiber in the Rumen

The results showed that the rate of degradation (fraction c) of NDF were no significantly different among *Leucaena leucocephala* forage edible parts. The extent of degradation (fraction a + b) of NDF in *Leucaena* forage were significantly ($P < 0.01$) higher in the leaves than in the pods and twigs respectively (Table 3) Figure (3). The effective degradation of NDF 2% was significantly ($P < 0.01$) higher in air dried, sun dried *Leucaena leucocephala* leaves than soaked plus sundried *Leucaena leucocephala* leaves, shooter, pods and twigs respectively. The effective degradation of NDF 5% was not significantly difference between the leaves but there were significant ($P < 0.01$) difference between the leaves and the other edible parts.

Table 3: NDF fraction degradability (%) of *Leucaena Leucocephalal* edible parts

Parts	a	b	c	PD	ED		
					2%	5%	8%
L.L. shooter	24.23[a]	50.7[c]	0.02[a]	74.9[b]	52.23[b]	41.07[a]	36.3[a]
Air dried *L.L.* leaves	27.33[ab]	58.9[d]	0.03[a]	68.3[c]	63.4[d]	50.43[b]	44.47c
Sun dried *L.L.* leaves	31.77[b]	47.57[bc]	0.035[a]	79.37[b]	61.87[d]	51.23[b]	46.17[c]
Soaked plus sundried *L.L.* leaves	32.13[b]	42.2[b]	0.04[a]	74.27[b]	59.7[c]	50.7[b]	45.77[c]
L.L. seed plus pods	27.27[ab]	38.4[a]	0.04[a]	65.67[a]	51.93[b]	43.33[a]	39.2[b]
L.L. twigs	25.27[a]	37.47[a]	0.04[a]	62.73[a]	49.8[a]	41.6[a]	37.53[ab]
SEM	1.56	1.79	0.005	1.8	0.69	0.74	0.70

(a) Readily degradable fraction; (b) Slow degradable fraction; (c) Rate of degradable fraction; (PD) Potential degradability; (ED) Effective degradability; (SEM) Standard Error of The Mean; a-f means with different superscript in the same row were significantly different ($P < 0.05$)



1 =shooter 2 = air dried leaves 3= sun dried leaves 4= soaked plus sun dried leaves 5= seed plus pods 6= twigs

Figure 3: The degradation characteristics of *Leucaena Leucocephala* forage NDF in the rumen

DISCUSSION

The nutritive value of tree legumes depends on the proportions of the leaf to stem that is eaten. Therefore, if the shoot is leafy with less lignified twigs, the nutritive value of the forage would be higher (Norton and Poppi 1995). The twigs were the slowest to degrade because they were more lignified than the other parts of the forage (Van Soest and Wine 1967). This was confirmed in our study. Pods did better probably due to the fact that fraction ‘a’ in pods contains non-protein nitrogen which is more degradable in the rumen than the other fractions. The whole shoot and leaves had similar characteristics probably because leaves form the bulk of the whole shoot. Twigs fell in between the other three parts because twigs are more lignified than leaves, and therefore less degradable. Most of the literature reviewed reported the degradability of leaves or whole shoots separately but not on all edible components of the *Leucaena leucocephala* forage, mainly because at the farm level the forage is fed to animals as one component containing leaves, twigs and pods in different proportions. The slow rate and the low degradation of nitrogen in the rumens has been explained by several workers (Jones 1965; Kumar and D’Mello 1995; Morrison and Mackie 1996) who attributed it to the presence of moderate levels of condensed tannins which bind feed protein, thus preventing it from more extensive degradation in the rumen. The nitrogen then became available for further digestion in the small intestine. Hence, condensed tannins in *Leucaena* forage have a beneficial effect to the ruminant because they protect feed protein from more extensive degradation in the rumen, by allowing nitrogen to be available for further digestion in the abomasums and small intestines. The rate of degradation is comparable with that reported by Larbi *et al.,* (1998) and Kamatali *et al.,* (1992). For the release of nitrogen Larbi *et al.,* (1998) obtained 13.5%, 57%, 70.6% and 0.041 for fraction a, b, a + b and c respectively, from 6 months old leaves and stems, while Kamatali *et al.,* (1992) obtained 25.1%, 59.5%, 84.6% and 0.131 for fraction a, b, a + b and c respectively, from 2-months old shoots. Bonsi *et al.,* (1995) obtained 14.5%, 80.0%, 94.5% and 0.031 for the same fractions. For the release of dry matter Larbi *et al.,* (1998) obtained 31.0%, 41.7%, 72.7% and 0.0651 for fraction a, b, a + b and c respectively; while Kamatali *et al.,* (1992) obtained 30.7%, 45.4%, 76.1% and 0.033 for fraction a, b, a + b and c respectively. The young the plant forage the more digestible it will be because it is less lignified and more susceptible to microbial degradation in the rumen (Van Soest 1994). The variation in results between this study and the different laboratories could be due to the climate and soils on which *Leucaena* grew; the stage of growth and the diet of experimental animals (Aii and Stobbs 1980) apart from lack of the standardized procedures for the nylon bag technique (Vanzant *et al.,* 1998). For example, Kamatali *et al.,* (1992) used 2-months old re-growth which were more degradable than older re-growths, and Larbi *et al.,* (1998) used 6-months old re-growths. It was concluded that *Leucaena* exhibited a sparing effect on nitrogen in the rumen by degrading slowly and to a lesser extent, which was attributed to the presence of moderate level of condensed tannins and by sun dried and soaking of *Leucaena leucocephala* leaves the adverse effect of tannin reduced to moderate level. The formation of tannin-protein complexes has been shown to protect dietary protein from excessive degradation in the rumen and enhance amino acid absorption and utilization by the host animal (Waghorn *et al.,* 1987). Therefore, it was recommended that *Leucaena* forage should be fed together with other protein supplements which have more readily degradable nitrogen to enhance more rapid production of ammonia in the rumen for microbial growth.

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